Radiological Dose and Risk Assessment of the Residual Windblown Tailings ARCO Bluewater Mill Site

January 1994

Submitted to:

U. S. Nuclear Regulatory Commission

Uranium Recovery Field Office

Denver, Colorado 80225

Submitted by:

Atlantic Richfield Company

Bluewater Uranium Mill

Post Office Box 638

Grants, New Mexico 87020

Prepared by:

Environmental Restoration Group, Inc.

12809 Arroyo de Vista NE

Albuquerque, New Mexico 87111

due 7-30-94

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

EXECUTIVE SUMMARY

This report presents a detailed analysis of the residual contamination of the surface soil within the restricted area of the Atlantic Richfield Company (ARCO) Bluewater Mill Site that exceeds the cleanup criterion for unrestricted release. The analysis presented in this report consists of calculating the maximum Effective Dose Equivalent (EDE) to an individual at the Site boundary as well as the total collective EDE to the population within 50 miles of the Site. This report also includes a cost-benefit analysis where the costs to perform further remediation is compared to the existing risk to the population from the radiological source term within the Exemption Boundary Area of the Site.

As discussed in ARCO's United States Nuclear Regulatory (NRC) approved Reclamation Plan, two independent studies identified approximately 600 acres of windblown tailings contaminated area. Of this 600 acres, 210 acres were in the Malpais (bad lands) area which was impractical to clean. Since the area only slightly exceeded the cleanup criteria and the remediation costs were very high relative to the person-rem saved, ARCO requested an exemption from the unrestricted release criteria for this area. The NRC approved the exemption. The remaining windblown tailings contaminated areas of the Site were to have been decontaminated to the release criteria by excavating the material and disposal on the tailings piles.

During the early stages of cleanup of the remaining windblown contaminated areas, it was discovered that it was not practical to decontaminate other windblown areas where the bedrock was near the surface. Once the scrapers and other equipment used to conduct the excavation reached bedrock, they were not effective in removing the slightly contaminated residual loose soil or soil within the interstitial rock formations. Upon discovering this restriction, ARCO met with the NRC staff. It was mutually decided to attempt to remove all available soil above the exposed bedrock using available standard construction equipment. After excavation, if the Ra-226 levels in the soil were still above the cleanup criteria, the NRC suggested that ARCO then request an exemption from the cleanup criteria for those areas.

ARCO proceeded under this guidance to remediate, to the maximum extent practical, the windblown tailings areas. Field gamma-ray verification measurements were made covering the entire area. An extensive soil sampling program was implemented with the samples analyzed for Ra-226. All areas where the data indicated that the criteria had not been met were revisited by a team made up of health physics, engineering, and construction personnel to determine whether additional effort could be undertaken. In areas where additional excavation was attempted, verification data were again taken to represent the current Site condition. This effort resulted in cleaning all but approximately 42 acres of the additional windblown area to below the unconditional release limits.

ARCO finds it necessary to request an exemption for these areas that do not meet the cleanup criteria. In support of this request, ARCO has conducted a very conservative radiological dose and risk assessment using Site verification data for areas of the Site that do not meet the cleanup criteria for unrestricted release. An Exemption Boundary Area was drawn that includes all areas where verification data indicate that the residual contamination exceeds the cleanup limits. The EPA Model, CAP88-PC was then used to calculate the EDE to an individual at the Site boundary and to the population within 50 miles of the Site. The results were compared to the most restrictive federal regulatory criteria, the United States Environmental Protection Agency's (EPA) National Emission Standards for Hazardous Air Pollutants (NESHAPs). These standards limit the dose to the public to 10 mrem/y, excluding exposure to radon. The exposure to radon from a remediated uranium mill tailings site is limited to that resulting from an average flux of 20 pCi/m^{2}s.

The results, based on very conservative assumptions, show that an individual at the Site boundary would receive only 3.0 mrem/y as a result of the surface soils within the Exemption Boundary Area. If all soils within the Exemption Boundary Area were decontaminated to the unconditional release criterion, the total EDE to an individual, including that from radon, at the Site boundary was calculated to be 3.4 mrem/y. This difference indicates that the off-site impact is less than if the entire area was decontaminated to meet the cleanup criteria.

These calculated doses may be compared to the EDE from natural radiation sources of more than 200 mrem/y. Using the EPA's risk factors and assuming that an individual lives at the Site boundary for 70 years, this corresponds to an individual life-time risk of a fatal cancer of 8×10^{-5}, which is well within EPA's acceptable risk range.

The collective EDE for the population within 50 miles of the Site was calculated as only 405 person-mrem/y. This EDE is distributed among approximately 65,000 people and is insignificant compared to the total collective EDE of more than 12 million person-mrem/y that population would be expected to receive from natural background radiation. If the current population within 50 miles remains constant, the calculations predict an additional fatal cancer risk of 0.011 within the group over the next 70 years. With this small probability of a fatal cancer, it is likely that this exemption will result in no additional impacts on the population.

A cost-benefit analysis was conducted to evaluate the cost of reducing these minimal radiation exposures further. While there are no assurances that any removal method would result in the decontamination to the release criteria, one method considered (ripping and removal of the rock) would have cost $630,000 to reduce the additional EDE to zero. This expenditure may save approximately 28 person-rem to the population over the next 70 years. This is equivalent to $23,000 per person-rem saved and is 23 times the NRC As Low As Reasonably Achievable (ALARA) criterion of $1,000 per person-rem saved.

Based on these analyses, ARCO is petitioning the NRC for an exemption from cleanup for the windblown area at the Site.

1.0 INTRODUCTION

The Bluewater Uranium Mill Site, owned by Atlantic Richfield Company (ARCO), is located approximately 10 miles from Grants, New Mexico as shown in Figure 1-1. Bluewater Village, the only significant population center near the Site, is located upwind about two miles west of the Site boundary. The current Bluewater Village population is estimated at 220 families. The nearest residence is located in the predominant downwind direction to the southeast at a straight-line distance of approximately 1.5 miles from the tailings areas. A land-use assessment (ARCO, 1989) of the area in 1989 revealed an additional 110 houses within 6 miles of the Site, primarily located to the south and southwest of the Homestake Uranium Mill. Other nearby population centers are the towns of Milan (8 miles) and Grants (10 miles). The 1990 census (CENSUS, 1992) population estimates for Milan and Grants were 1911 and 8626, respectively.

The geographical area in which the Site is located is considered semi-arid with an average annual precipitation of ten inches and a mean annual pan evaporation of approximately 70 inches. A down turn in the local economy began around 1980 due to lay offs within the uranium industry. Projections for the area out to the year 2020 indicate minimal future growth and development for the area. Additional information regarding the local environment has been recently published in Supplement to Environmental Report for the Decommissioning and Reclamation of the Bluewater Uranium Mill (ARCO, 1993).

Initial work leading to the decommissioning of the Bluewater Uranium Mill (Mill) and reclamation of the tailings areas began in 1982. The Mill decommissioning was completed in 1990 under a Decommissioning Plan approved by the United States Nuclear Regulatory Commission (NRC). Reclamation of the tailings areas began in 1991, under an NRC-approved Reclamation Plan (ARCO, 1990). Initial reclamation work consisted of placing fill on the decommissioned Mill and the engineered fill areas for the Mill building debris.

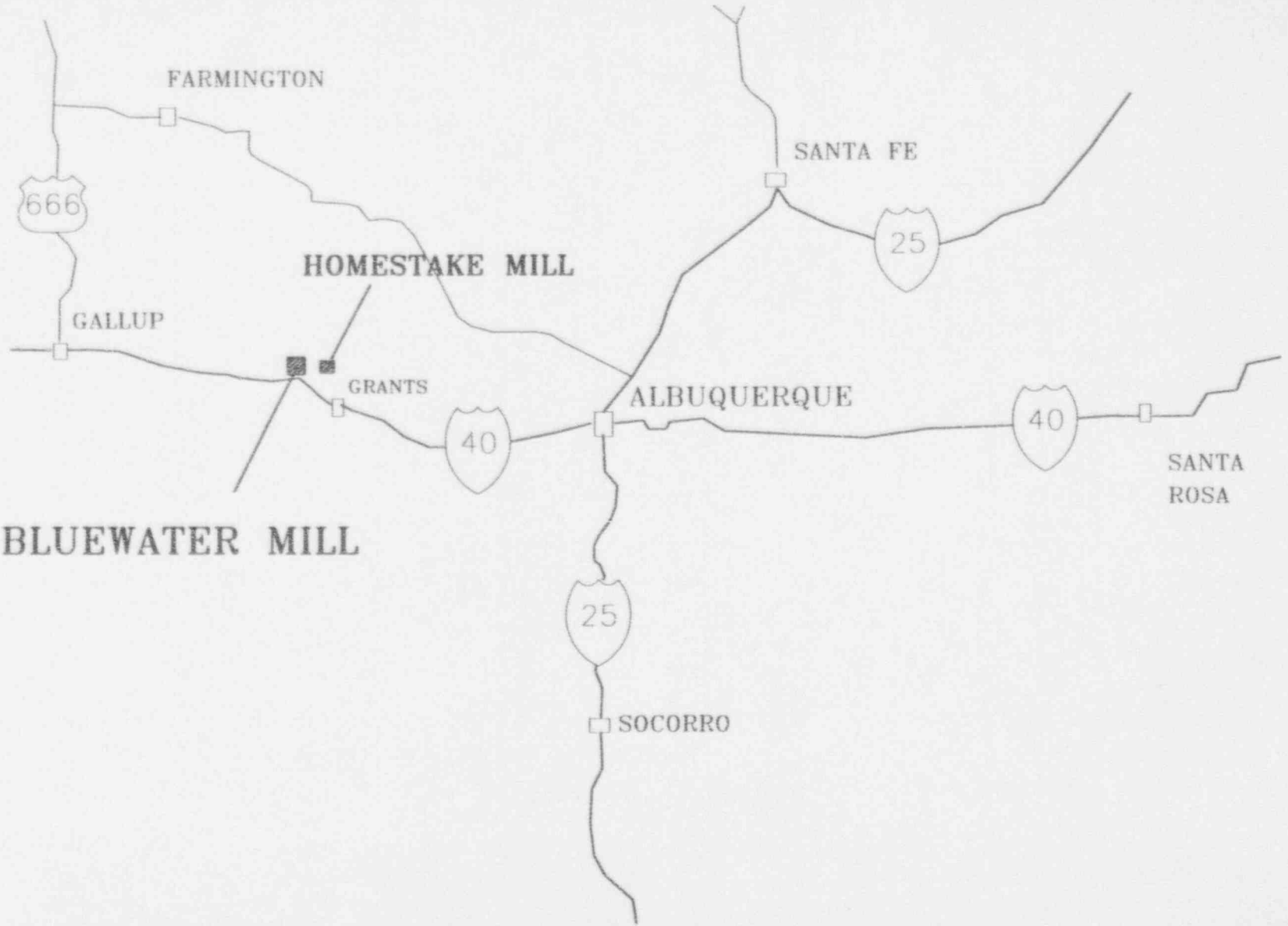


FIGURE 1-1
BLUEWATER URANIUM MILL
SITE MAP (REGIONAL)

ANDERSON ENGINEERING CO., INC.
Long Beach, California · Salt Lake City, Utah · Grants, New Mexico
Telephone (505) 731-4998 Fax (505) 731-7809
CIVIL ENGINEERS CONSTRUCTION MANAGERS

ATLANTIC RICHFIELD COMPANY
BLUEWATER MILL

DRAWN BY: MJD
ENGINEER: TDA
APPROVED:
DATE: 11-22-82
HORIZ SCALE: NO SCALE
VERT SCALE:
REFERENCE:

Reclamation work continued in 1992 when contaminated dikes and wind-blown tailings areas were excavated, with the excavated material being placed on the Main Tailings Pile (MTP). Contaminated soils and residues from four evaporation ponds were also placed on the MTP. Some of the MTP recontouring tasks were completed including, regrading the side slopes of the MTP. Wicks were installed in the slimes area to dewater and consolidate the slimes.

During 1993, reclamation work continued with additional contaminated material consolidation, removal of all but one evaporation pond, placement of engineered fill over the ore storage area, revegetation of the disturbed areas, and the placement of radon barrier material on the Carbonate Tailings Pile and the southern portion of the MTP. Figure 1-2 shows the current Site features and the restricted area boundary.

The Reclamation Plan presents the results of two studies that identified approximately 600 acres with windblown tailings that exceeded the cleanup criterion of 5 pCi/g above background (i.e., 6.9 pCi/g). Of that area, approximately 210 acres were covered with lava-flow rock (Malpais Exclusion Area) and were exempted from the cleanup criteria by the NRC. Under the Reclamation Plan, the remaining 390 acres of windblown tailings areas, referred to in this report as "windblown areas", were to be decontaminated by removing the contaminated soil to meet the unrestricted release criteria.

In obtaining the Malpais Exclusion Area exemption, ARCO demonstrated (ARCO, 1990 Appendix C) that much of the 210-acre Malpais (bad lands) Exclusion Area was impractical to clean and that the risk to equipment operators working in the area was significantly greater than the radiological risk of living adjacent to the area. ARCO proposed that the NRC exempt this area from remediation with the exception of the low-lying areas accessible to standard industrial equipment.

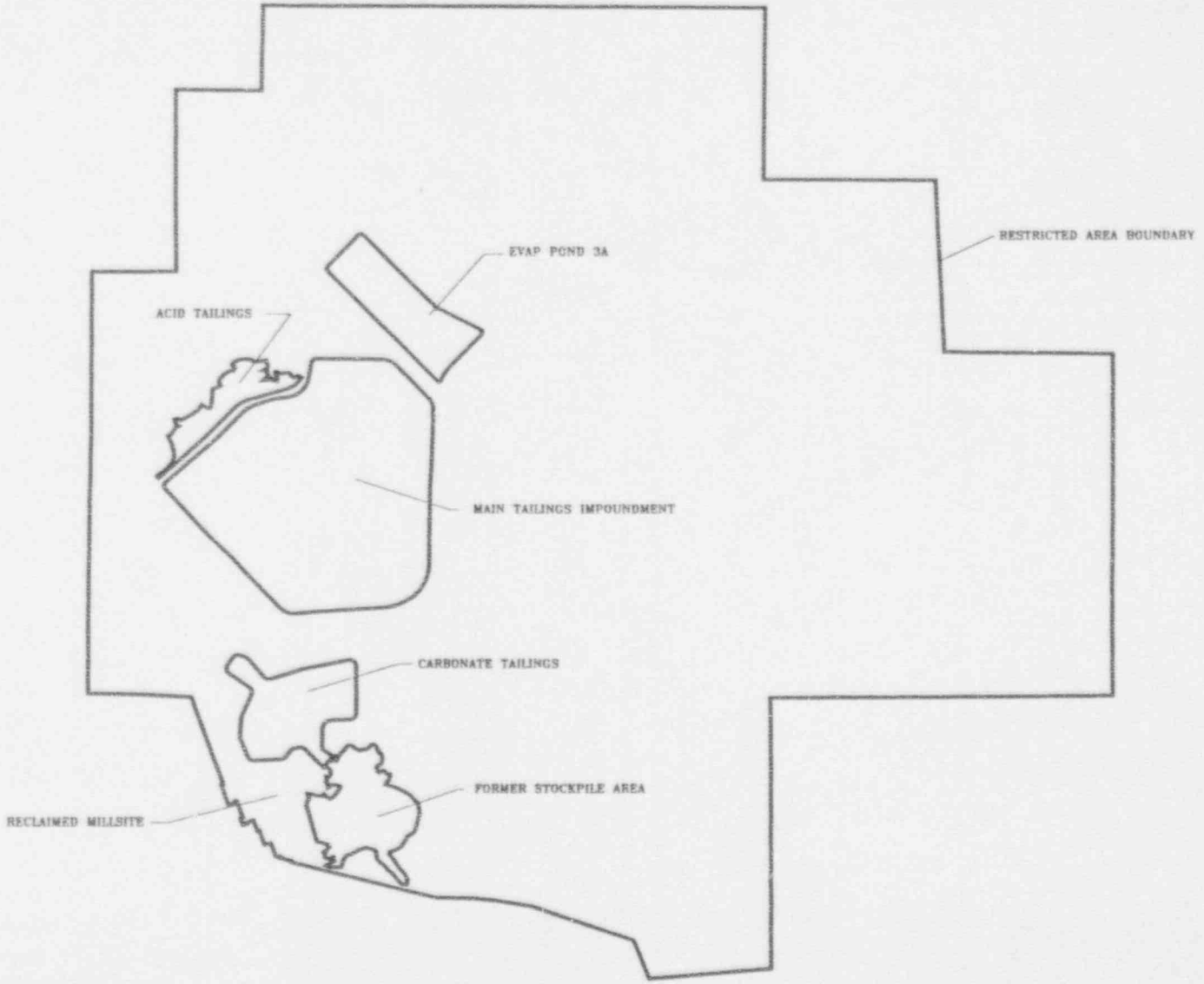


FIGURE 1-2
BOUNDARY OF REMEDIATED SITE

ANDERSON ENGINEERING CO., INC.
Long Beach, California · Salt Lake City, Utah · Grants, New Mexico
Telephone (801) 731-4888 Fax (801) 731-7809
CIVIL ENGINEERS CONSTRUCTION MANAGERS

ATLANTIC RICHFIELD COMPANY

DATE 12-23-83
HORIZ. SCALE 365 SCALE

Similar exemptions had been made by the Department of Energy at sites under the Uranium Mill Tailings Remedial Action Project. Approximately 42 acres of the low-lying areas were excavated to the extent practical to comply with the Reclamation Plan.

During the cleanup of the windblown areas, it became apparent that it was impractical to decontaminate some of the areas where the rock outcrop was near or at the surface to the levels for unrestricted release. In these areas, scrapers and other equipment used to remove the available soil merely redistributed the loose soil on and around the bedrock or exposed lava flow structures, once the rock outcrop was encountered.

ARCO met with the NRC staff to discuss how to proceed in these areas. It was mutually decided to attempt to remove all available soil above the exposed bedrock using standard construction equipment. After excavation to the extent practicable, if the Ra-226 levels in the soil were still above the cleanup criteria and the risk was insignificant, the NRC suggested that ARCO request an exemption from the cleanup criteria for these areas.

ARCO proceeded with the cleanup of the windblown areas, consistent with its discussions with the NRC staff. Details of the cleanup and various removal efficiency tests have been presented in the "Windblown Contamination Cleanup Report", Atlantic Richfield Company, October 1992 (ARCO, 1992). This report was submitted to the NRC on October 30, 1992.

ARCO has recently made additional efforts to decontaminate the windblown areas. Only about 42 of the original 400 acres of windblown area currently exceed the cleanup criteria of 5 pCi/g above background (i.e., 6.9 pCi/g). An "Exemption Boundary Area" has been defined that contains these elevated areas. While areas within the Exemption Boundary Area exceed the cleanup limit, the area-weighted average Ra-226 concentration in the top 15 cm layer for the windblown and Malpais Exclusion areas is 4.4 pCi/g above background, or slightly below the cleanup criterion.

The Ra-226 cleanup criterion of 5 pCi/g above background for surface soils was established for unrestricted use of land. It is a level at which a home built on the land would have acceptable indoor radon levels. The restricted area at the Site, which includes the proposed exemption area, must be deeded to the government for long-term surveillance. The significant unlikelihood of future residental development within the restricted area is an important consideration in evaluating the proposed exemption.

Section 2.0 of this report consists of a description of the reclamation and reclamation status. Sections 3.0 and 4.0 of this report consist of characterization data and a radiological dose and risk assessment to support the request for an exemption from the cleanup criteria. Section 5.0 consists of a cost-benefit analysis where the cost of additional cleanup is compared to the NRC ALARA cost criteria.

2.0 RECLAMATION ACTIVITIES

2.1 Cleanup of Windblown Contaminated Areas

ARCO's NRC-approved Reclamation Plan (ARCO, 1990) identifies areas contaminated by windblown tailings. In order to reclaim these areas, soils were to be excavated until the area complies with the unrestricted release criteria of 5 pCi/g Ra-226 concentration in the top 15 cm of soil, as prescribed in 10 CFR Part 40, Appendix A. Approximately 390 acres, in addition to the 210-acre Malpais Exclusion Area, were identified as windblown areas requiring remediation. Approximately 30 acres of the 390 acres were known to be major rock outcrops and rock bluffs that would be difficult, if not impossible, to excavate. Typical terrain in this area is shown in Figure 2-1.

In early March 1992, prior to the start of cleanup, ARCO conducted operational tests to assess the effectiveness of standard industrial equipment in removing contaminated soil. It was discovered that the scrapers effectively removed the contaminated soil with the exception of areas where the soil layer was very thin and the contamination extended to the bedrock. For these areas, the scraper bowl tended to float over the loose rocks and bedrock outcrop. While some of the soil was removed, a large percentage was redistributed as interstitial fill among the outcrop rocks. Attempts at exerting downward pressure on the scrapers and additional dozers to push the scrapers (see Figure 2-2) resulted in potential extensive damage to the equipment without increasing the effectiveness of the cleanup. Concerns also grew regarding the safety of personnel during such activities.

After the scrapers could no longer effectively remove soil, additional soil was removed by blading the loose soil into windrows using motor graders. The scrapers were then used to remove the bladed material. Photographs of these activities are shown in Figures 2-3 and 2-4.

Figure 2-1 Rock Outcrop Area that could not be Remediated

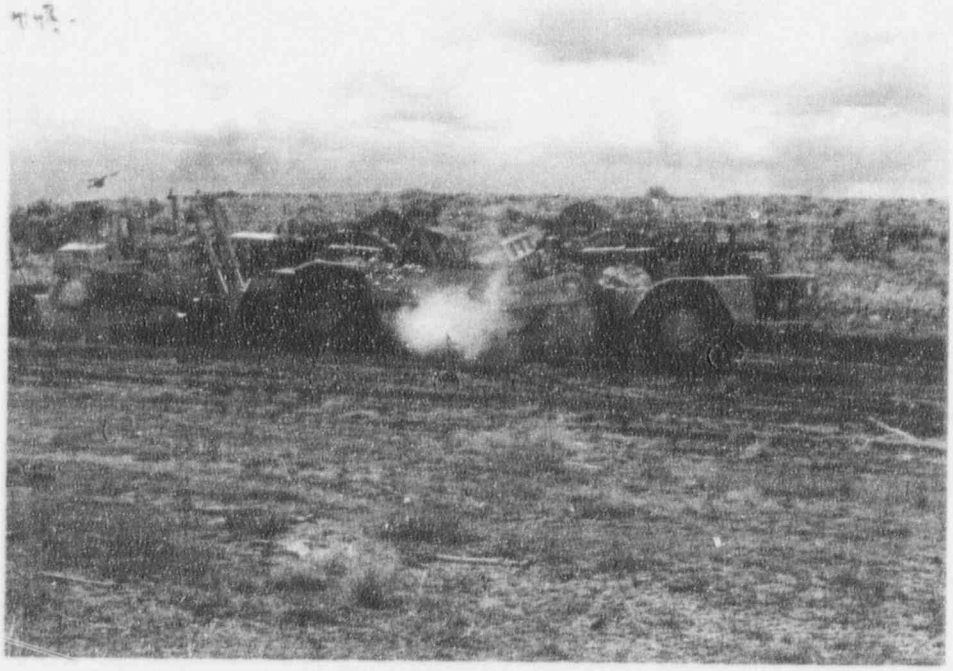


Figure 2-2 Remediation Activities in Rock Outcrop Area

Figure 2-3 Grader Blading Loose Soil in Rock Outcrop Area

Figure 2-4 Scraper Removing Bladed Windrows

On March 25, 1992, ARCO's staff met with the NRC's Uranium Recovery Field Office (URFO) staff in Denver to discuss the excavation restrictions encountered in the tests. The NRC suggested that ARCO attempt the excavation of contaminated soil until it reached the bedrock formation, so as to pick up the contaminated soil to the maximum extent practical with available standard construction equipment such as scrapers, graders, dozers, and loaders. After this excavation attempt, if the Ra-226 levels remain above the cleanup standards, ARCO should petition for an exemption from the cleanup criteria based on the health risk from the residual contamination.

ARCO continued excavating the areas identified for decontamination until the field measurements indicated that the criteria had been met or the area could not be further excavated due to the excavation restrictions. In addition, the low-lying areas of the Malpais Exclusion Area were excavated using the same approach as that used in the other windblown areas. Figure 2-5 shows an excavation in the Malpais Exclusion Area where contaminated soils in the low-lying alluvial areas were being removed.

Upon completion of this work, ARCO submitted a report entitled, Windblown Contamination Cleanup Report (ARCO, 1992), describing the windblown cleanup. Estimated Ra-226 concentrations, based on field gamma-ray measurements correlated to soil sample analyses, were used to estimate the success of the cleanup. Final verification measurements had not been made at that time.

Soon after submitting the Windblown Contamination Cleanup Report, verification activities began in the windblown areas that had been decontaminated. One hundred composite surface soil samples were collected for each 1,000-ft. by 1,000-ft. grid block and analyzed for Ra-226 according to the procedures in the Reclamation Plan.

Figure 2-5 Excavation in Low-Lying Area of Malpais Exclusion Area

Gamma-ray verification measurements were made for each 33-ft. by 33-ft. (approximately 100 m^2) grid block. After the initial data were available, all areas where the gamma-ray count rates or the soil sample results indicated that the Ra-226 concentration may exceed the cleanup criterion were reevaluated to determine whether further remediation was practical. Further attempts at cleaning approximately 120 acres were made during 1993, with some of the areas being attempted more than once. After all reasonable efforts had been made to decontaminate the areas, the final verification measurements were made. These data are presented in Section 3.

2.2 Current Reclamation Status

Figure 2-6 shows the basic features of the Site. Evaporation Pond 3A is the only evaporation pond that remains out of a total of seven that originally covered approximately 300 acres. The other six ponds have been decommissioned and placed on the tailings piles and the areas decontaminated to meet the cleanup criteria. The MTP and the Acid Tailings Pile will be covered for radon control and stabilized according to the requirements of the ARCO Reclamation Plan. The Carbonate Tailings, reclaimed mill area, and the former Ore Storage Area have all been remediated and stabilized according to the Reclamation Plan. All windblown tailings material that can be practically removed has been excavated and placed on the tailings. A 2.4-feet thick radon barrier has been placed on the sands portion of the MTP (southern half of the pile). The slimes area and a portion of the slimes/sands area (mixed area) of the MTP have been covered with low activity off-pile material. Final radon barrier will be applied to these areas in 1994.

The excavated windblown areas and the areas previously covered by the evaporation ponds are indicated in Figure 2-6 by the shading. The low-lying alluvial areas within the Malpais Exclusion Area were cleaned to the extent practical, but the entire Malpais Exclusion Area was exempted from the cleanup standard by the NRC in the Reclamation Plan (ARCO, 1990). The low-lying areas that were remediated are also identified in Figure 2-6.

FIGURE 2-6
CURRENT SITE FEATURES
AND EXCAVATED AREAS

ANDERSON ENGINEERING CO., INC.
Long Beach, California — Salt Lake City, Utah — Grants, New Mexico
Telephone (801) 731-4588 Fax (801) 731-1809
CIVIL ENGINEERS CONSTRUCTION MANAGERS

ATLANTIC RICHFIELD COMPANY
BLUEWATER MILL NEW MEXICO

DRAWN BY:	MJD
ENGINEER:	SDA
APPROVED:	
DATE:	1-17-84
HORIZ. SCALE:	NO SCALE
VERT. SCALE:	
REFERENCE:	

The off-pile material from the evaporation ponds and windblown areas was primarily placed on top of the northern half of the MTP. The final radon barrier material has been placed on the southern portion of the MTP and on the Carbonate Tailings Pile. This effectively reduced the gamma exposure rates at the periphery of the tailings piles to near background levels. These low exposure rates allowed the use of verification procedure, Method B, for all off-pile areas of the Site. This method is presented in "Verification Procedure for Cleanup of Contaminated Lands" which is part of the Reclamation Plan, Appendix C.

3.0 EXEMPTION AREA

Figure 3-1 shows the Exemption Boundary Area for which ARCO is requesting an exemption. The area includes all off-pile areas that could not be remediated to meet the unrestricted release criteria for surface soils. Also within this boundary is the Malpais Exclusion Area, the uncovered Acid Tailings, the covered Carbonate Tailings Pile, the covered Stock Pile Area, and the partially covered MTP. All tailings areas, the Malpais Exclusion Area, and the covered Stock Pile Area will be remediated to comply with the Reclamation Plan. Only a small fraction of the off-pile areas within the Exemption Area Boundary currently do not comply with the standard for unrestricted release. The risks to the off-site population from these areas are the focus of this risk assessment set forth in Section 4.0 of this report.

For the purpose of the discussion below, the "windblown area" is defined as all areas within the exemption boundary that are not the Malpais Exclusion Area, a tailings pile, or the former Ore Storage Area and reclaimed mill Site. Therefore, after reclamation has been completed, the only exposed surface soils with levels above 5 pCi/g above background (i.e., 6.9 pCi/g), averaged over a depth of 15 cm and an area of 100 m^2, consist of portions of the windblown area and Malpais Exclusion Area. Since the Malpais Exclusion Area has already been exempted from the cleanup criteria, the additional areas within the Exemption Area Boundary that are above the cleanup criteria are the focus of this exemption request. However, the dose and risk assessment considers all exposed surface soils within the Exemption Area Boundary.

3.1 Windblown Areas within Exemption Area Boundary

For the windblown area within the exemption boundary, soil samples were taken at the specified locations to a depth of 15 cm where possible. When 15 cm of soil was not available, the sample was prepared by taking the available soil. Where a 15 cm mixture of rock and soil was available, the fines including rock with a diameter up to approximately 1.5

inches were taken to prepare the sample. The soil sample results for each of the four surface soil samples within each 200 ft. by 200 ft. grid block are provided in Appendix A.

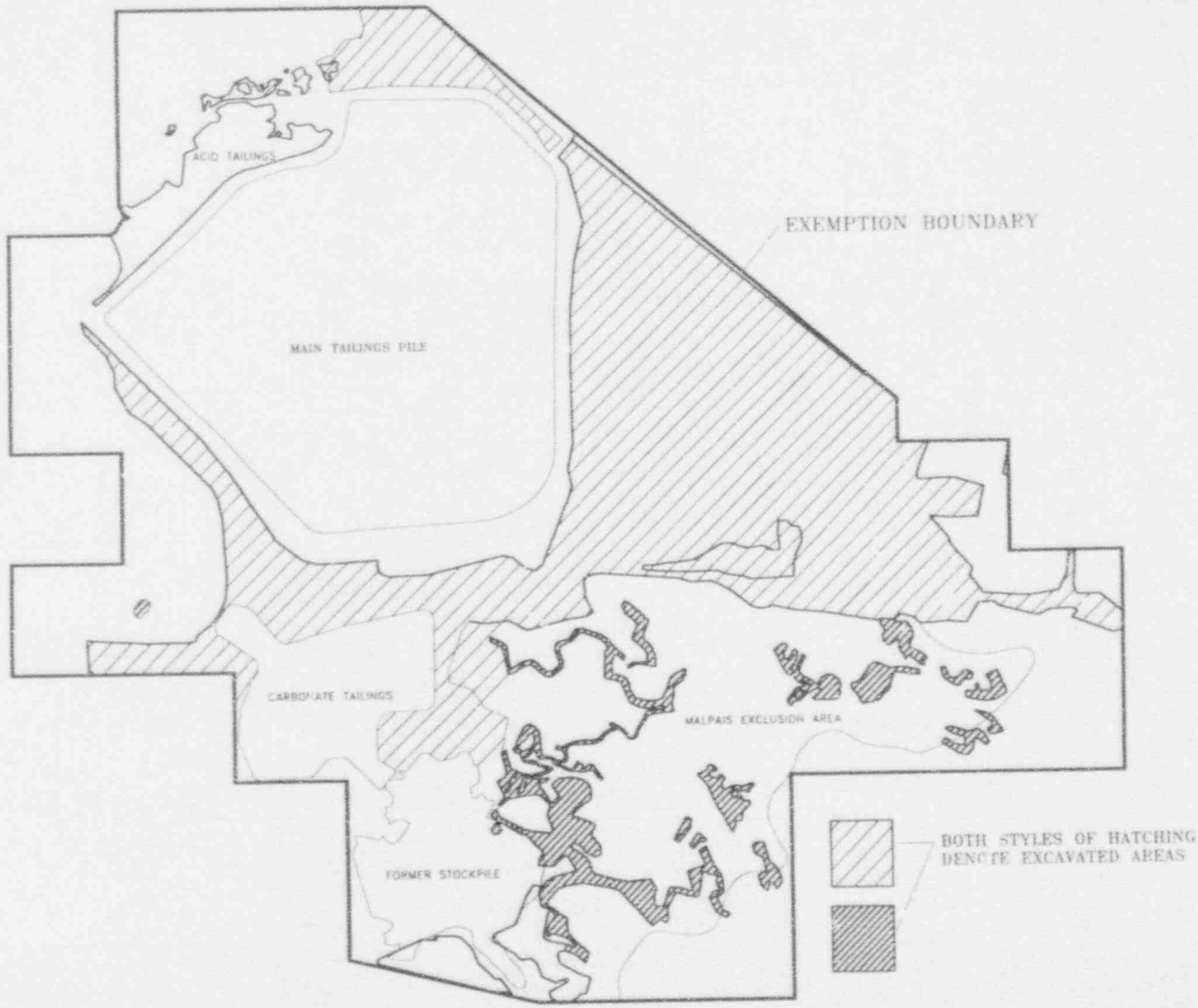


FIGURE 3-1
EXEMPTION BOUNDARY
AREA

ANDERSON ENGINEERING CO., INC.
CIVIL ENGINEERS CONSTRUCTION MANAGERS

ATLANTIC RICHFIELD COMPANY
BLUEWATER MILL NEW MEXICO

The actual Ra-226 concentrations in soil data do not directly correspond to values related to the cleanup criteria since the criteria specifies a limit for the average Ra-226 concentration in the top 15 cm of soil. The NRC has concurred in a procedure (Gonzales, 1994) for use at the Department of Energy(DOE) Uranium Mill Tailing Renewal Act (UMTRA) Project sites for situations where large cobbles or rocks (large fraction) are interspersed within the fine grain soils (small fraction). The procedure is used to calculate the "bulk average Ra-226 concentration" in a 15 cm thick layer by using the average relative weight percentages of the large and small fractions, the average measured Ra-226 concentration in the large fraction, and the measured Ra-226 concentrations of the small fractions. The bulk average Ra-226 concentration is obtained by calculating a mass-weighted average concentration, considering the percentages of soil and rock in the soil/rock matrix. For conservatism, the calculation for the Ra-226 concentration is biased high by using the upper 95 percent confidence level of the measured average Ra-226 concentration in the large fraction, and the lower 95 percent confidence level of the average large particle fraction mass percentage.

A procedure similar to that used by the DOE was applied to these areas within the Exemption Boundary Area and the Ra-226 concentration values adjusted accordingly. The procedure was modified to correct for the percentage of bedrock in the top 15 cm layer. The data and calculations to develop the bulk average Ra-226 concentrations are presented in Appendix B. The last column in Appendix A consists of the bulk average Ra-226 concentrations for the grid blocks within the Exemption Boundary Area. The use of the bulk average Ra-226 concentration is still considered very conservative from a risk assessment perspective since the radon emanation from rock is a small fraction of that from soil.

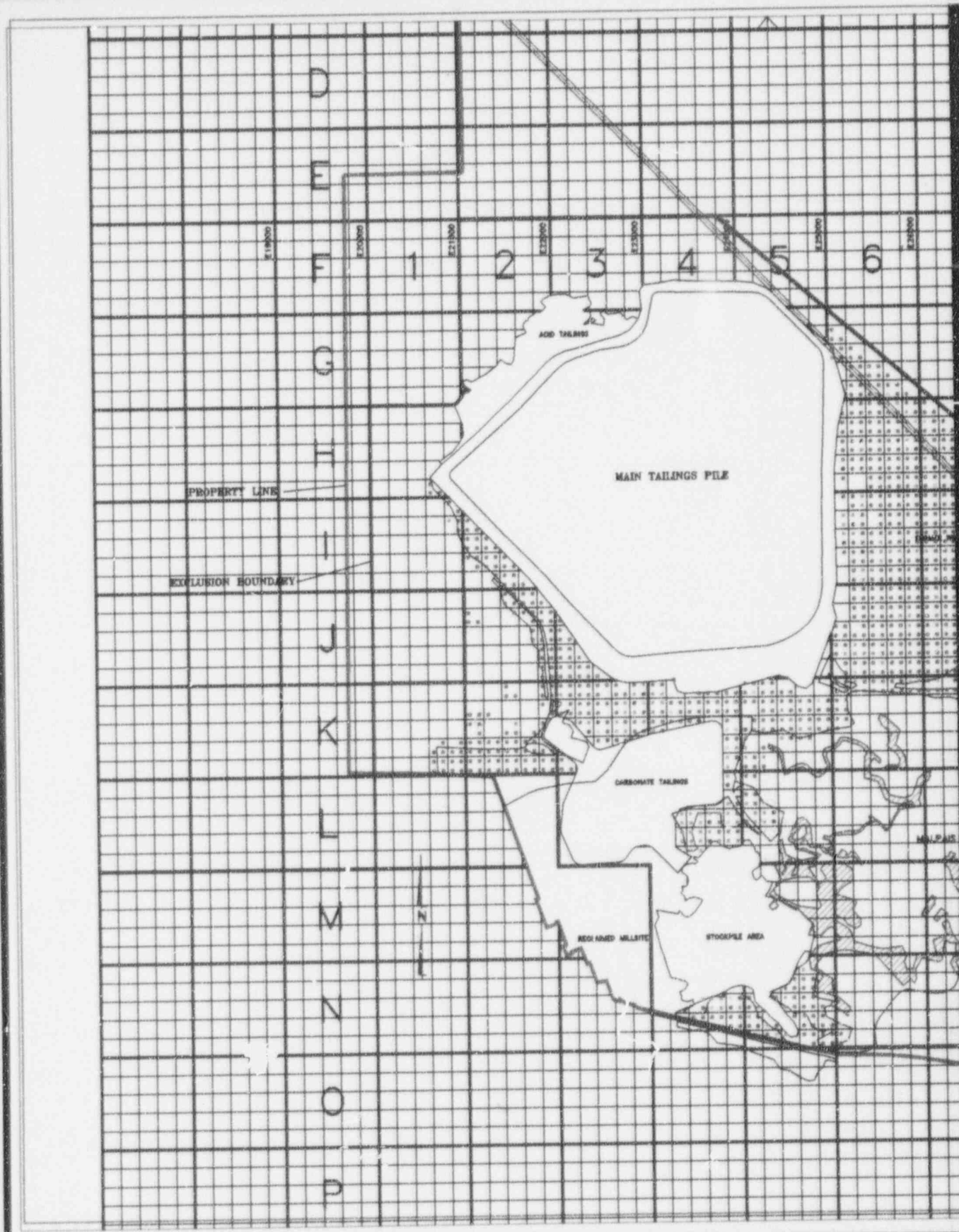
The bulk average Ra-226 concentrations are represented by Figure 3-2. The color corresponds to a Ra-226 soil concentration range as given in the legend on Figure 3-2. All red, orange, and light green areas represent samples where the Ra-226 concentration was

greater than the 6.9 pCi/g cleanup criteria. Actual numerical data corresponding to the sampling locations are given in Appendix A.

3.2 Malpais Exclusion Area

Characterization of the Malpais Exclusion Area was done to support a risk assessment presented in Appendix C of the Reclamation Plan. Soil samples were taken at 68 locations yielding an average Ra-226 concentration of 10.6 pCi/g, or 9.7 pCi/g above background. It was estimated that 25 percent of the mass in the top layer was lava rock. Ra-226 concentrations in the lava rock within the Malpais Exclusion Area were measured at eight locations yielding a mean concentration of 4.1 pCi/g and a standard error of 0.7 pCi/g. The Ra-226 concentration in a lava sample collected at a nearby uncontaminated location was 1.4 pCi/g.

An experiment was done to determine the average depth of soil in the Malpais Exclusion Area. It was estimated that an average of eight inches of soil exists but 25 percent of the mass within the top 15 cm is made up of lava rock. Using an average Ra-226 concentration of 10.6 pCi/g and the upper 95% confidence level of 5.4 pCi/g for the lava rock, then the mass-weighted average for the upper 15 cm layer is calculated as 9.3 pCi/g which is 7.4 pCi/g above the background soil concentration. This "bulk average Ra-226 concentration" will be used in the risk assessment set forth in Section 4.0, when appropriate. The application of small sample theory (Student's t distribution) was used for the above calculations. Calculations are provided in Appendix B.



DATE	REVISION	NO.

ANDERSON ENGINEERING CO., INC.

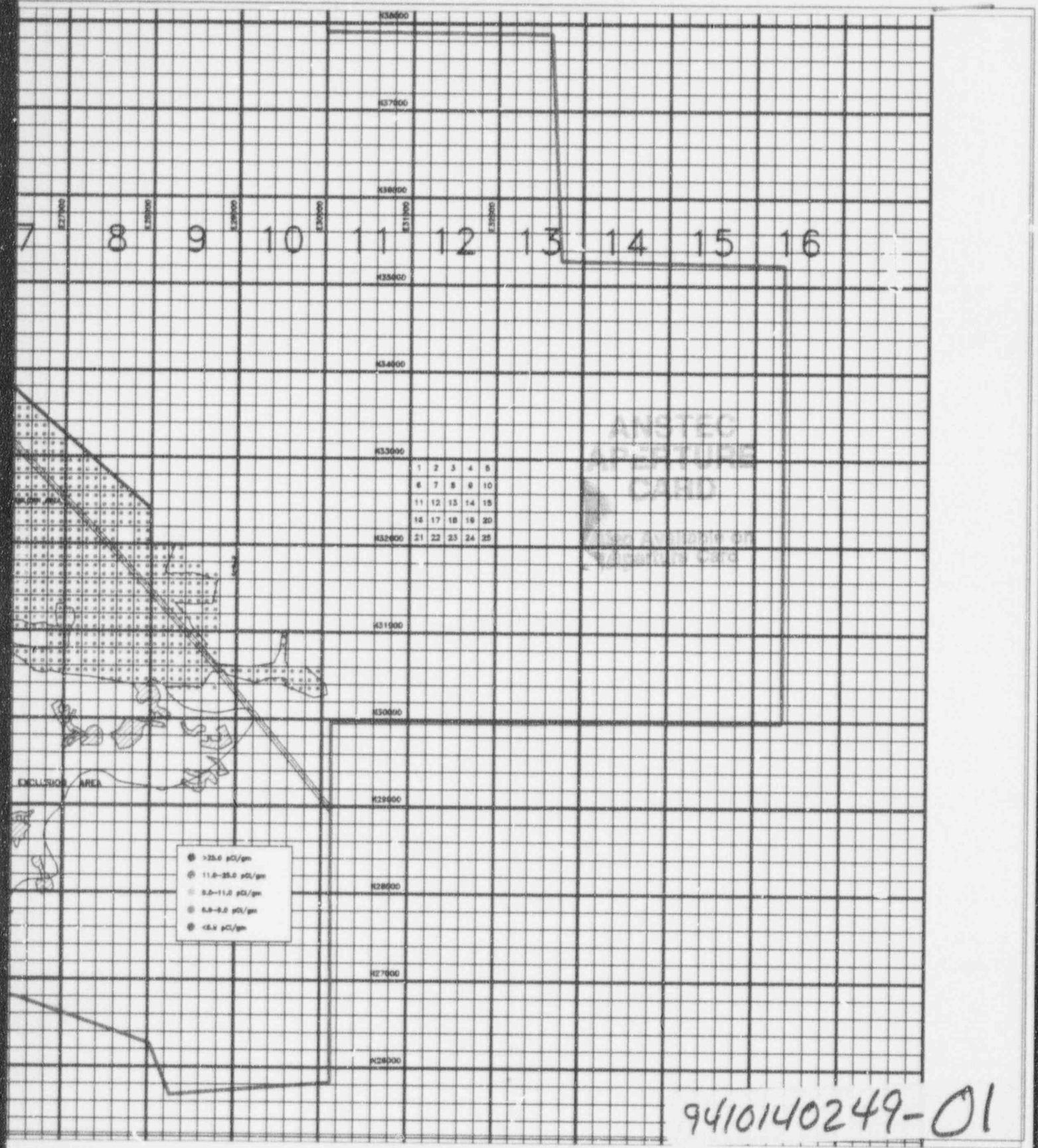
Long Beach, California · Salt Lake City, Utah · Grants, New Mexico

Telephone (801) 731-4586 Fax (801) 731-7809

CIVIL ENGINEERS CONSTRUCTION MANAGERS

BULK A

RA



9410140249-01

FIGURE 3-2

VERAGE Ra-226 CONCENTRATION

NGES FOR SURFACE LAYER

ATLANTIC RICHFIELD COMPANY

BEAVER CREEK WELL

DRAWN BY: MJD

ENGINEER: SDH

APPROVED: KB

DATE: 1-4-94

HORIZ. SCALE: NO SCALE

VERT. SCALE:

REFERENCE

The actual average concentrations used in this analysis are probably high estimates since the data were taken prior to the remediation of the low-lying areas. Approximately 42 acres of the 210-acre Malpais Exclusion Area have been remediated to the extent practical since the original data were taken.

4.0 RADIOLOGICAL DOSE AND RISK ASSESSMENT

The radiological risk associated with the areas that exceed the cleanup criteria for unrestricted release has been calculated using actual data from the Site. After remediation of the windblown tailings areas, the verification procedures were followed by taking one hundred soil samples per 1,000-ft. by 1,000-ft. grid block and analyzing the samples in the laboratory for Ra-226. These samples provide a very precise measure of the mean Ra-226 concentration for the grid block. The emission rates for each grid block have been calculated and used to calculate the off-site Effective Dose Equivalent (EDE) for each grid block. The total EDE is then obtained by summing the EDE's from each grid block.

The cleanup standards for uranium mill processing sites were developed primarily to minimize radiation exposure via the airborne pathway. The radon flux limit of 20 pCi/m^{2}s for remediated piles was developed to limit the radon concentration at the site boundary to 3 pCi/l, where the site boundary was considered to be close to the edge of the pile. The Ra-226 cleanup criterion of 5 pCi/g for surface soils was established for unrestricted use of land. It is a level at which homes may be constructed on the land without excessive indoor radon concentrations.

The Site does not fit the model on which the standard was based in that the Site is approximately 4,500 acres with residual windblown contaminated areas interspersed among remediated tailings piles, former mill site, and former ore storage area. The entire area will be deeded to the government for long-term surveillance. This, along with the undesirability of the Site for future development, make it very unlikely that buildings will be located on the Site.

In determining whether the residual activity above the cleanup criteria results in an acceptable risk, the maximum individual and population EDE might be compared to the risk to an individual living at a remediated pile Site boundary where the radon concentration is

3 pCi/l. Another comparison is to an individual living in a house built on soil with Ra-226 concentration at the cleanup criterion of 5 pCi/g above background. These possible baseline cases are known to produce a much higher risk than is presented by the Site under its proposed future use. We have therefore decided that a more appropriate baseline risk is the risk to the off-site population assuming that the entire windblown area within the exemption boundary were contaminated at the regulatory limit for unrestricted use, or 5 pCi/g above background. This will therefore be considered the baseline case for risk assessment purposes.

4.1 Radiological Source Term Development

The radioactive emission source term arising from the contaminated soils consists of radioactive particulate and Radon-222. The method for developing the source term is discussed separately below.

4.1.1 Particulate Source Term

The method for developing source terms for emissions from uranium mill tailings sites is defined in the NRC Regulatory Guide 3.59, "Methods for Estimating Radioactive and Toxic Airborne Source Terms for Uranium Milling Operations".

The radioactive particulate source term is defined by:

$$S = E_e A C f N (1 - R) \qquad \text{(Eq 1)}$$

where S = Radionuclide source (Ci/y) of individual radionuclide

E_e = Emission factor ($g/m^2/yr$)

A = Exposed contaminated surface area (m^2)

C = Radionuclide concentration in material (Ci/g)

N = Activity enrichment ratio of concentration in dust/bulk material

R = Control factor on releases (unitless)- See Appendix C of the NRC Reg. Guide 3.59

f = fraction of each radionuclide present

and the emission factor, E_w is defined by:

$$E_w = [(3.156E+7)/0.5] \Sigma R_i F_i \qquad \text{(Eq 2)}$$

where F_i = Annual average frequency of occurrence of wind speed groups obtained from joint relative frequency wind distribution for the site.

R_i = Dusting rate at average wind speed for wind speed groups for particles ≤ 20 μm in diameter (g/m^2s). See Table 1 of Reg. Guide 3.59.

3.156E+7 = Number of seconds per year

0.5 = Fraction of total dust loss by particles ≤ 20 μg in diameter.

The residual contamination at the Site is considered windblown and resides primarily on the surface. The average bulk Ra-226 concentration in the top 15 cm layer, as defined in Section 3.1, will be used as the particulate source term. This is still very conservative since in many of the areas of the Site, only a very thin layer of soil or soil/rock matrix lies above the bedrock.

The radionuclide mix on the Site was determined for various areas by ARCO as part of the radiological protection program, prior to beginning the reclamation. These mixes are presented in the NRC-approved ARCO Radiation Protection Plan. The residual contamination should best be approximated by that in the original Secondary Windblown Areas as shown in the Reclamation Plan (ARCO, 1990) where the U-nat, Ra-226, Th-230 ratio was measured to be 0.10:0.63:0.27.

The activity enrichment ratio chosen for this Site is 2.5 as suggested in NUREG-0706 Vol.III, "Final Generic Environmental Impact Statement on Uranium Milling", p.G-10. The control factor, R, in Eq. 1 was set equal to zero. This is considered conservative since the rocky terrain and vegetation cover will reduce the resuspension of the particulate, perhaps as much as 20 percent. However, no credit for this was taken.

The emission factor for the site, E_w, is calculated using Equation 2 and Table 2 emission factors in NRC Regulatory Guide 3.59 and cumulative wind speeds measured at ARCO's Bluewater Uranium Mill Site from 1982 through 1985. The data and calculations are presented in Table 4-1.

Table 4-1. Parameters for Calculating Site Emission Factors

Wind Speed		Resuspension rate	Frequency of	Product
knots	mph	R_s (g/m^2)	Occurrence, F_s	R_sF_s (g/m^2)
0-3	1-3	0	0.278	0
4-6	4-6	0	0.296	0
7-10	7-9	3.92E-7	0.177	6.938E-8
11-16	10-14	9.68E-6	0.165	1.597E-6
17-21	15-19	5.71E-5	0.064	3.654E-6
21+	20+	2.08E-4	0.021	4.368E-6
				ΣR_sF_s = 9.69E-6

$E_w = (3.156E+7/0.5)\ \Sigma R_sF_s$

$= 612\ g/m^2y$

The airborne particulate radionuclide source term as presented in Equation 1 is developed for each radionuclide of interest as input into the CAP88-PC code. For ease of input for the Site, the source term for each radionuclide will be calculated and normalized to 1 pCi/g Ra-226 over 1 m^2, using the radionuclide mixture presented above. For Ra-226, the total particulate source term using Equation 1 is calculated as follows:

$$S = E_wACfN(1 - R)$$
$$= (612\ g/m^2y)(1\ pCi/g)(1)(2.5)(1)$$
$$= 1530\ pCi/m^2y$$

where 2.5 was selected for the activity enhancement factor, N, and no credit was taken for release control (R).

A correction to the radionuclide source term is made for the activity carried by the smaller respirable fraction of the particulate. For this Site, it is assumed that 30 percent of the particulate radioactivity is carried by particulate associated with 0-10 μm particles with an AMAD of 5μm (NUREG-0706). Therefore a factor of 0.3 is applied to the total radionuclide particulate source term. Applying the 0.3 factor and the radionuclide mix ratios, the particulate source term per unit area per pCi/g Ra-226 is:

459 pCi/m^{2}y	Ra-226
197 pCi/m^{2}y	Th-230
36 pCi/m^{2}y	U-238
36 pCi/m^{2}y	U-234

4.1.2 Radon Source Term

The excess radon flux from surface soils may be conservatively estimated by assuming that the elevated Ra-226 concentrations are restricted to a depth of 15 cm or less and all the radon generated and released to the soil pore space is released to the atmosphere. An emanation coefficient of 0.32 is used based on data obtained in the windblown areas at the Site. For each 1 pCi/g of elevated Ra-226 activity in the top 15 cm layer, the flux release rate (pCi/m^{2}s) can be calculated as follows,

$$(1\ \text{pCi/g})(0.32)(15\ \text{cm})(10^4\ \text{cm}^2/\text{m}^2)(1.6\ \text{g/cm}^3)(2.1\text{E-}6\ \text{s}^{-1}) = 0.16\ \text{pCi/m}^2\text{s}$$

where 2.1E-6 s^{-1} is the radon decay constant and 1.6 g/cm^3 is the density of soil.

4.2 Site Boundary Incremental Effective Dose Equivalent Estimate

The off-site dose calculations were made using the CAP88-PC, Version 1.0 code (EPA,1992) developed by the EPA. It is based on the Gaussian plum model and is intended for evaluating low level chronic releases from sites similar to that at the Site. It has recently been used by the EPA in evaluating off-site impacts from the Site as well as other uranium processing facilities (EPA 1993). Area sources may be used and there is no limitation on the distance from the source at which doses may be calculated.

The CAP88-PC code requires that particulate source terms and radon source terms be used in separate runs. CAP88-PC estimates the Radon Daughter Concentration (RDC) in Working Level units by calculating the radon daughter equilibrium fraction as a function of the time of travel, using a speed of 3.5 meters per second. The calculation of the equilibrium fraction starts at 150 meters (equilibrium fraction = 0.267) and terminates at a maximum equilibrium fraction of 0.698 at 19,551 meters.

Figure 1-2 shows the current Site with the proposed boundary of the remediated Site that will be transferred to a government agency for long-term surveillance. The Site wind data indicate that the predominant winds are from the NNW direction. Therefore, in determining the exposure to the maximum exposed individual, the individual was placed on the southern boundary of the Site.

A conservative approach was taken to calculate the maximum EDE to a hypothetical individual living at the Site boundary. The large-area source was addressed by taking each 1,000-ft. by 1,000-ft. grid block as a single area source. The distance from the center of the grid block to the Site boundary in the SSE direction was calculated for each of the 46 grid blocks and the EDE calculated at that distance and direction. The EDE to the maximum exposed individual was calculated by summing the maximum EDE from each of the individual grid block runs in the SSE direction at the Site boundary.

This is considered very conservative since the actual maximum would be much less than the sum of the maximum values.

It is recognized that the maximum off-site EDE from several grid blocks (e.g. Grid Blocks L-9 and F-2) may not be in the SSE direction due to the proximity of the Site boundary in a direction other than SSE. This was evaluated and found to not invalidate the approach since the number of these grid blocks as well as the relative size of their source terms are small.

The particulate radionuclide and radon gas release rates per year were calculated for each of the 1,000-ft. by 1,000-ft. grid blocks. This was done by converting the values developed in Sections 4.1.1 and 4.1.2 into releases per one million square feet area per year per pCi/g of Ra-226 in the soils. These conversions resulted in the following emission rates from each grid block per pCi/g Ra-226 in the top 15 cm of soil.

Radionuclide	Release rate (Ci/y per pCi/g)
Rn-222	4.7E-1
Ra-226	4.3E-5
Th-230	1.8E-5
U-238	3.4E-6
U-234	3.4E-6
Pa-234	3.4E-6
Th-234	3.4e-6

NESHAPS

CAP88-PC default parameters for particle size and class, state agricultural data, and food supply sources were used. The EPA had recently developed wind data (STARANHM) and population data (BLUEWATE.POP) files in assessing off-site exposures near the Site (EPA,1993). After reviewing the files for reasonableness, these files were adopted for use in this analysis.

The release rates were entered into the CAP88-PC code and the EDE calculated at the nearest Site boundary in the SSE direction from the center of each 1,000-ft. by 1,000-ft. grid. The CAP88-PC output for the particulate source term is provided as Appendix C; the CAP88-PC output for the radon source term is provided as Appendix D. The results for each grid block were used in spread sheets for further calculations.

The calculation of the maximum individual effective dose equivalent from residual contamination within the Exemption Boundary Area is shown in the spread sheet presented as Table 4-2. The third and fourth columns of the spreadsheet provide the annual effective dose equivalent (EDE) per pCi/g resulting from particulate and radon emissions for each grid block. Other columns provide the bulk average Ra-226 concentrations and area percentages for each of the geological regions within a primary (1000-ft. by 1000-ft.) grid block. The windblown area is divided into the Chinle Sandstone, Lava, and Limestone geological regions. The Malpais Exclusion Area is treated as a separate region within the exemption boundary.

The EDE from the radon and particulate source terms is calculated by taking the product of the EDE per pCi/g and the average Ra-226 for each primary grid block, after subtracting the background concentration of 1.9 pCi/g. The average Ra-226 for the grid block is equal to the sum of the products of the concentration for each geological region and the area percentage for the geological region. The total maximum individual EDE is conservatively estimated by summing the maximum EDE for each grid block.

The Ra-226 concentrations used for the calculations shown in Table 4-2 are the "bulk average Ra-226" values above background for each region as described in Appendix B. The maximum individual EDE for this case is 3.0 mrem/y. Table 4-3 presents the baseline case in which the Ra-226 concentration for the Malpais Exclusion Area and the windblown areas are assumed to be equal to the unconditional release criterion, 5 pCi/g above background, or 6.9 pCi/g. The maximum individual EDE above background for this baseline case is

3.4 mrem/y. Therefore, the dose to the maximum exposed individual from the surface soils is 0.4 mrem/y less than if the surface soils were decontaminated to the unrestricted release criteria. This is predictable from the data in Table 4-2 which shows that the average Ra-226 concentration for only seven of the 46 Grid Blocks exceeds the 5 pCi/g limit.

The 3.0 mrem/y that the individual receives from particulate and radon originating from the Exemption Boundary Area may be compared to the NRC's limit of 100 mrem/y to any member of the public from operating facilities (10 CFR Part 20). The 3.0 mrem/y EDE to the maximum exposed individual is composed of 2.5 mrem/y from particulate and 0.5 mrem/y from radon daughter exposures. Another appropriate comparison is to the 10 mrem/y EDE limits in the EPA's National Emission Standards for Hazardous Air Pollutants, 40 CFR Part 61, Subpart I. Radon is specifically excluded from this limit. Subpart T addresses the disposal of uranium mill tailings and limits the radon flux to 20 pCi/m^{2}s. Using the release rate developed in Section 4.1.2 and an average Ra-226 concentration of 4.4 pCi/g for the windblown area within the Exemption Boundary Area, the average flux from these areas would be approximately 0.7 pCi/m^{2}s, or 4 percent of the Subpart T limit for the disposal of uranium mill tailings. The 2.5 mrem/y from particulates from the Exemption Boundary Area is only 25 percent of the 10 mrem/y limit. In addition, the radon emissions are less than 4 percent of the radon flux limit.

A third comparison is to compare the additional EDE to the maximum exposed individual, to that which he/she receives from natural background. The 3.0 mrem/y is a small fraction of the approximately 200 mrem/y that the average person in the United States receives from natural radiation.

$\frac{4.2(.09)+(5.5)(0.15)+7.4(0.72)}{.09+0.15+0.72}$

Table 4–2. Maximum Individual EDE at the Site Boundary Using Bulk Average Ra–226 Concentrations

1000 X 1000

Grid Block	Distance to Boundary (m)	Particulate EDE mrem/y per pCi/g	Radon EDE mrem/y per pCi/g	Avg. Ra–226 (pCi/g)				Area Percentage				Particulate EDE (mrem/y)		Radon EDE (mrem/y		Total EDE mrem/y
				Chinle	Lava	Limestone	Malpais	Chinle	Lava	Limestone	Malpais	Windblown	Malpais	Windblown	Malpais	
F–2	2828	8.9E–04	2.0E–04				7.4				0.99	0.0000	0.0065	0.0000	0.0015	0.008
F–3	2851	8.8E–04	2.0E–04				7.4				0.93	0.0061	0.0014	0.0000	0.0014	0.009
F–4	2954	8.3E–04	1.8E–04				7.4				0.82	0.0050	0.0011	0.0000	0.0011	0.007
F–5	3233	7.2E–04	1.6E–04				7.4				0.27	0.0014	0.0003	0.0000	0.0003	0.002
G–2	2465	1.1E–03	2.5E–04				7.4				0.42	0.0034	0.0008	0.0000	0.0008	0.005
G–3	2504	1.1E–03	2.4E–04				7.4				0.05	0.0004	0.0001	0.0000	0.0001	0.001
G–5	1814	2.0E–03	3.9E–04				7.4	0.03			0.10	0.0015	0.0003	0.0000	0.0003	0.002
G–6	2838	8.6E–04	1.9E–04	2.0				0.35				0.0006	0.0000	0.0001	0.0000	0.001
H–1	2007	1.6E–03	3.5E–04		1.3				0.86			0.0018	0.0000	0.0004	0.0000	0.002
H–6	2589	1.0E–03	2.3E–04	2.1				0.91				0.0019	0.0000	0.0004	0.0000	0.002
H–7	2543	1.1E–03	2.4E–04	0.6				0.60				0.0004	0.0000	0.0001	0.0000	0.000
I–1	1367	2.4E–03	5.3E–04		4.3			0.00	0.99			0.0102	0.0000	0.0023	0.0000	0.012
I–2	1730	2.0E–03	4.5E–04		0.9				0.35			0.0006	0.0000	0.0001	0.0000	0.001
I–6	2249	1.3E–03	2.9E–04	5.9		4.0		0.32		0.62		0.0057	0.0000	0.0019	0.0000	0.008
I–7	2224	1.3E–03	3.0E–04	0.8		1.7		0.36		0.64		0.0018	0.0000	0.0008	0.0000	0.003
I–8	2091	1.5E–03	3.3E–04	0.5				0.76				0.0006	0.0000	0.0001	0.0000	0.001
J–2	1382	3.0E–03	6.7E–04		0.7				0.98			0.0021	0.0000	0.0005	0.0000	0.003
J–3	1453	2.7E–03	6.0E–04		1.5				0.21			0.0008	0.0000	0.0002	0.0000	0.001
J–6	1689	2.1E–03	4.7E–04			1.9				0.97		0.0039	0.0000	0.0014	0.0000	0.005
J–7	1904	1.9E–03	3.8E–04			2.8				1.00		0.0053	0.0000	0.0014	0.0000	0.007
J–8	1879	2.0E–03	3.9E–04	0.3		0.3		0.69		0.31		0.0006	0.0000	0.0003	0.0000	0.001
J–9	1290	3.5E–03	7.3E–04	0.3				1.00				0.0011	0.0000	0.0002	0.0000	0.001
K–1	161	1.5E–01	3.2E–02		0.1				1.00			0.0150	0.0000	0.0032	0.0000	0.018
K–2	988	5.4E–03	1.1E–03		1.2				0.96			0.0062	0.0000	0.0013	0.0000	0.007
K–3	1085	4.6E–03	9.8E–04		5.9				0.64			0.0174	0.0000	0.0037	0.0000	0.021
K–4	1175	4.1E–03	8.5E–04		6.8				0.51			0.0143	0.0000	0.0030	0.0000	0.017
K–5	1198	4.0E–03	8.3E–04		2.0		7.4		0.57		0.40	0.0164	0.0025	0.0009	0.0025	0.022
K–6	1296	3.5E–03	7.3E–04		4.2	5.5	7.4		0.09	0.15	0.72	0.0229	0.0039	0.0044	0.0039	0.035
K–7	1585	2.8E–03	5.2E–04			0.0	7.4			0.35	0.65	0.0125	0.0025	0.0002	0.0025	0.018
K–8	1580	2.6E–03	5.3E–04			–0.1	7.4			0.56	0.44	0.0083	0.0017	0.0002	0.0017	0.012
K–9	1293	3.5E–03	7.3E–04	0.6		0.0	7.4	0.28		0.55	0.17	0.0051	0.0009	0.0005	0.0009	0.007
K–10	488	1.8E–02	3.9E–03	0.7		0.9	7.4	0.63		0.19	0.02	0.0139	0.0006	0.0060	0.0006	0.021
L–4	809	7.8E–03	1.7E–03		16.7		7.4		0.43		0.01	0.0561	0.0001	0.0121	0.0001	0.068
L–5	852	7.1E–03	1.5E–03		10.5		7.4		0.27		0.69	0.0564	0.0077	0.0042	0.0077	0.076
L–6	911	6.3E–03	1.3E–03				7.4				1.00	0.0466	0.0096	0.0000	0.0096	0.066
L–7	1040	5.0E–03	1.0E–03				7.4				1.00	0.0370	0.0074	0.0000	0.0074	0.052
L–8	1240	3.8E–03	7.8E–04				7.4				0.71	0.0200	0.0041	0.0000	0.0041	0.028
L–9	1215	3.9E–03	8.1E–04				7.4				0.66	0.0190	0.0040	0.0000	0.0040	0.027
L–10	492	1.9E–02	3.9E–03				7.4				0.36	0.0506	0.0104	0.0000	0.0104	0.071
M–5	520	1.8E–02	3.5E–03				7.4		0.05		0.44	0.0521	0.0114	0.0000	0.0114	0.075
M–6	547	1.8E–02	3.2E–03				7.4				1.00	0.1332	0.0237	0.0000	0.0237	0.181
M–7	658	1.2E–02	2.4E–03				7.4				0.82	0.0728	0.0146	0.0000	0.0146	0.102
N–4	74	4.2E–01	8.6E–02		3.8				0.18			0.2905	0.0000	0.0595	0.0000	0.350
N–5	165	1.4E–01	3.0E–02		7.2		7.4		0.51		0.13	0.6509	0.0297	0.1097	0.0297	0.820
N–6	196	9.8E–02	2.0E–02		3.9		7.4		0.03		0.67	0.4955	0.0989	0.0023	0.0989	0.696
N–7	274	5.5E–02	1.1E–02				7.4				0.15	0.0590	0.0118	0.0000	0.0118	0.083
															Total EDE	3.0

Total Particulate = 2.5
Total Radon EDE = 0.5

Table 4–3. Maximum Individual EDE at the Site Boundary Assuming Areas Contaminated at Limit for Unrestricted Release

Grid Block	Distance to Boundary (m)	Particulate EDE mrem/y per pCi/g	Radon EDE mrem/y per pCi/g	Avg. Ra–226 (pCi/g)				Area Percentage				Particulate EDE (mrem/y)		Radon EDE (mrem/y		Total EDE
				Chinle	Lava	Limestone	Malpais	Chinle	Lava	Limestone	Malpais	Windblown	Malpais	Windblown	Malpais	mrem/y
F–2	2828	8.9E–04	2.0E–04				5.0				0.99	0.0000	0.0044	0.0000	0.0010	0.005
F–3	2851	6.8E–04	2.0E–04				5.0				0.93	0.0041	0.0009	0.0000	0.0009	0.006
F–4	2954	8.3E–04	1.8E–04				5.0				0.82	0.0034	0.0007	0.0000	0.0007	0.005
F–5	3233	7.2E–04	1.6E–04				5.0				0.27	0.0010	0.0002	0.0000	0.0002	0.001
G–2	2485	1.1E–03	2.5E–04				5.0				0.42	0.0023	0.0005	0.0000	0.0005	0.003
G–3	2504	1.1E–03	2.4E–04				5.0				0.05	0.0003	0.0001	0.0000	0.0001	0.000
G–5	1814	2.0E–03	3.9E–04				5.0	0.03			0.10	0.0010	0.0002	0.0000	0.0002	0.001
G–6	2888	8.6E–04	1.9E–04	5.0				0.35				0.0015	0.0000	0.0003	0.0000	0.002
H–1	2007	1.6E–03	3.5E–04		5.0				0.86			0.0069	0.0000	0.0015	0.0000	0.006
H–6	2589	1.0E–03	2.3E–04	5.0				0.91				0.0046	0.0000	0.0010	0.0000	0.006
H–7	2543	1.1E–03	2.4E–04	5.0				0.60				0.0033	0.0000	0.0007	0.0000	0.004
I–1	1567	2.4E–03	5.3E–04		5.0			0.00	0.99			0.0119	0.0000	0.0026	0.0000	0.014
I–2	1730	2.0E–03	4.5E–04		5.0				0.35			0.0035	0.0000	0.0008	0.0000	0.004
I–6	2249	1.3E–03	2.9E–04	5.0		5.0		0.32		0.62		0.0061	0.0000	0.0021	0.0000	0.008
I–7	2224	1.3E–03	3.0E–04	5.0		5.0		0.36		0.64		0.0065	0.0000	0.0022	0.0000	0.009
I–8	2091	1.5E–03	3.3E–04	5.0				0.76				0.0057	0.0000	0.0013	0.0000	0.007
J–2	1382	3.0E–03	6.7E–04		5.0				0.98			0.0147	0.0000	0.0033	0.0000	0.018
J–3	1453	2.7E–03	6.0E–04		5.0				0.21			0.0028	0.0000	0.0006	0.0000	0.003
J–6	1680	2.1E–03	4.7E–04			5.0				0.97		0.0102	0.0000	0.0028	0.0000	0.013
J–7	1904	1.9E–03	3.8E–04			5.0				1.00		0.0095	0.0000	0.0023	0.0000	0.012
J–8	1879	2.0E–03	3.9E–04	5.0		5.0		0.69		0.31		0.0100	0.0000	0.0034	0.0000	0.013
J–9	1290	3.5E–03	7.3E–04	5.0				1.00				0.0175	0.0000	0.0037	0.0000	0.021
K–1	161	1.5E–01	3.2E–02		5.0				1.00			0.7500	0.0000	0.1600	0.0000	0.910
K–2	988	5.4E–03	1.1E–03		5.0				0.96			0.0259	0.0000	0.0053	0.0000	0.031
K–3	1085	4.6E–03	9.8E–04		5.0				0.64			0.0147	0.0000	0.0031	0.0000	0.018
K–4	1175	4.1E–03	8.5E–04		5.0				0.51			0.0105	0.0000	0.0022	0.0000	0.013
K–5	1198	4.0E–03	8.3E–04		5.0		5.0		0.57		0.40	0.0194	0.0017	0.0024	0.0017	0.025
K–6	1296	3.5E–03	7.3E–04		5.0	5.0	5.0		0.09	0.15	0.72	0.0168	0.0026	0.0041	0.0026	0.026
K–7	1585	2.6E–03	5.2E–04			5.0	5.0			0.35	0.65	0.0130	0.0017	0.0028	0.0017	0.019
K–8	1560	2.6E–03	5.3E–04			5.0	5.0			0.56	0.44	0.0129	0.0012	0.0029	0.0012	0.018
K–9	1293	3.5E–03	7.3E–04	5.0		5.0	5.0	0.28		0.55	0.17	0.0175	0.0006	0.0051	0.0006	0.024
K–10	488	1.8E–02	3.9E–03	5.0		5.0	5.0	0.63		0.19	0.02	0.0757	0.0004	0.0325	0.0004	0.109
L–4	809	7.8E–03	1.7E–03		5.0		5.0		0.43		0.01	0.0170	0.0001	0.0036	0.0001	0.021
L–5	852	7.1E–03	1.5E–03		5.0		5.0		0.27		0.69	0.0341	0.0052	0.0020	0.0052	0.047
L–6	911	6.3E–03	1.3E–03				5.0				1.00	0.0315	0.0065	0.0000	0.0065	0.045
L–7	1043	5.0E–03	1.0E–03				5.0				1.00	0.0250	0.0050	0.0000	0.0050	0.035
L–8	1240	3.8E–03	7.8E–04				5.0				0.71	0.0135	0.0028	0.0000	0.0028	0.019
L–9	1215	3.9E–03	8.1E–04				5.0				0.66	0.0129	0.0027	0.0000	0.0027	0.018
L–10	492	1.9E–02	3.9E–03				5.0				0.36	0.0342	0.0070	0.0000	0.0070	0.048
M–5	520	1.6E–02	3.5E–03				5.0		0.05		0.44	0.0352	0.0077	0.0000	0.0077	0.051
M–6	547	1.8E–02	3.2E–03				5.0				1.00	0.0900	0.0160	0.0000	0.0160	0.122
M–7	658	1.2E–02	2.4E–03				5.0				0.82	0.0492	0.0098	0.0000	0.0098	0.069
N–4	74	4.2E–01	8.6E–02		5.0				0.18			0.3822	0.0000	0.0783	0.0000	0.460
N–5	165	1.4E–01	3.0E–02		5.0		5.0		0.51		0.13	0.4494	0.0201	0.0762	0.0201	0.566
N–6	198	9.8E–02	2.0E–02		5.0		5.0		0.03		0.67	0.3415	0.0668	0.0029	0.0668	0.478
N–7	274	5.5E–02	1.1E–02				5.0				0.15	0.0399	0.0080	0.0000	0.0080	0.056
															Total EDE	3.4

Total Particulate =	2.8
Total Radon EDE =	0.6

4.3 Off-Site Population Dose Assessment

The collective EDE to the off-site population was calculated using CAP88-PC. The total EDE to all individuals within 50 miles was calculated to assure that the total off-site impact to the population was acceptable. The U. S. EPA-developed population file, BLUEWATE.POP, and wind file, STARANHM.WND, were used.

Off-site population runs were made for unit concentrations of Ra-226 in the soils within the exemption boundary. A spread sheet was used to calculate the total collective EDE in a manner similar to that described in Section 4.2 for the maximum individual EDE. The collective EDE per pCi/g of Ra-226 in the surface soils for a 1,000-ft. by 1,000-ft. grid block within the Exemption Boundary Area was calculated for particulate and for radon emissions. The CAP88-PC output for these runs is included as Appendix D.

The spreadsheet (Table 4-4) to calculate the collective EDE to the population within 50 miles of the Site considers the bulk average Ra-226 concentration in each of the primary grid blocks within the Exemption Boundary Area, and the percentage of grid block area that is in the Malpais Exclusion Area and the geological regions of the windblown area. The natural background concentration was first subtracted from the Ra-226 concentrations. Note that some grid blocks consist of tailings piles, covered former Ore Storage Area, covered Site, or clean areas outside the Malpais Exclusion Area (Grid Blocks N-6, N-7, M-7, L-8, L-9, L-10, and K-10). These areas do not contribute to the source terms of interest and have been omitted from the calculations. Since some of the areas do not contribute to the source terms of interest, the percentages given in Table 4-4 do not always sum to unity. Multiplying the normalized collective EDE by the area percentage and the Ra-226

concentration, the collective EDE from each major grid block is shown in the last column of Table 4-4. The total collective EDE to the population within 50 miles of the Site is calculated to be 405 mrem/y.

Table 4–4. Collective EDE for Population Within Fifty Miles of Site Using Bulk Average Ra–226 Concentrations

Grid Block	Particulate EDE mrem/y per pCi/g	Radon EDE mrem/y per pCi/g	Avg. Ra–226 (pCi/g)				Area Percentage				Particulate EDE (mrem/y)		Radon EDE (mrem/y)		Total EDE mrem/y
			Chinle	Lava	Limestone	Malpais	Chinle	Lava	Limestone	Malpais	Windblown	Malpais	Windblown	Malpais	
F–2	1.9E+00	4.9E–01				7.4				0.99	0.0000	13.8772	0.0000	3.5496	17.4
F–3	1.9E+00	4.9E–01				7.4				0.93	13.1320	3.3590	0.0000	3.3590	19.9
F–4	1.9E+00	4.9E–01				7.4				0.82	11.5011	2.9419	0.0000	2.9419	17.4
F–5	1.9E+00	4.9E–01				7.4				0.27	3.7962	0.9710	0.0000	0.9710	5.7
G–2	1.9E+00	4.9E–01				7.4				0.42	5.9052	1.5105	0.0000	1.5105	8.9
G–3	1.9E+00	4.9E–01				7.4				0.05	0.6889	0.1762	0.0000	0.1762	1.0
G–5	1.9E+00	4.9E–01				7.4	0.03			0.10	1.3913	0.3560	0.0000	0.3560	2.1
G–6	1.9E+00	4.9E–01	2.0				0.35				1.3300	0.0000	0.3402	0.0000	1.7
H–1	1.9E+00	4.9E–01		1.3				0.86			2.1242	0.0000	0.5433	0.0000	2.7
H–6	1.9E+00	4.9E–01	2.1				0.91				3.6309	0.0000	0.9287	0.0000	4.6
H–7	1.9E+00	4.9E–01	0.6				0.60				0.6840	0.0000	0.1750	0.0000	0.9
I–1	1.9E+00	4.9E–01		4.3			0.00	0.99			8.0801	0.0000	2.0668	0.0000	10.1
I–2	1.9E+00	4.9E–01		0.9				0.35			0.6036	0.0000	0.1544	0.0000	0.8
I–6	1.9E+00	4.9E–01	5.9		4.0		0.32		0.62		8.3136	0.0000	3.1724	0.0000	11.5
I–7	1.9E+00	4.9E–01	0.8		1.7		0.36		0.64		2.6144	0.0000	1.2772	0.0000	3.9
I–8	1.9E+00	4.9E–01	0.5				0.76				0.7220	0.0000	0.1847	0.0000	0.9
J–2	1.9E+00	4.9E–01		0.7				0.98			1.3007	0.0000	0.3327	0.0000	1.6
J–3	1.9E+00	4.9E–01		1.5				0.21			0.5900	0.0000	0.1509	0.0000	0.7
J–6	1.9E+00	4.9E–01			1.9				0.97		3.5161	0.0000	1.3968	0.0000	4.9
J–7	1.9E+00	4.9E–01			2.8				1.00		5.3200	0.0000	1.8468	0.0000	7.2
J–8	1.9E+00	4.9E–01	0.3		0.3		0.69		0.31		0.5717	0.0000	0.3985	0.0000	1.0
J–9	1.9E+00	4.9E–01	0.3				1.00				0.5700	0.0000	0.1458	0.0000	0.7
K–1	1.9E+00	4.9E–01		0.1				1.00			0.1900	0.0000	0.0486	0.0000	0.2
K–2	1.9E+00	4.9E–01		1.2				0.96			2.1886	0.0000	0.5599	0.0000	2.7
K–3	1.9E+00	4.9E–01		5.9				0.64			7.1744	0.0000	1.8351	0.0000	9.0
K–4	1.9E+00	4.9E–01		6.8				0.51			6.6150	0.0000	1.6921	0.0000	8.3
K–5	1.9E+00	4.9E–01		2.0		7.4		0.57		0.40	7.7936	1.4386	0.5550	1.4386	11.2
K–6	1.9E+00	4.9E–01		4.2	5.5	7.4		0.09	0.15	0.72	12.4089	2.5894	2.9296	2.5894	20.5
K–7	1.9E+00	4.9E–01			0.0	7.4			0.35	0.65	9.1390	2.3377	0.1706	2.3377	14.0
K–8	1.9E+00	4.9E–01			−0.1	7.4			0.56	0.44	6.0808	1.5824	0.2216	1.5824	9.5
K–9	1.9E+00	4.9E–01	0.6		0.0	7.4	0.28		0.55	0.17	2.7611	0.6258	0.3478	0.6258	4.4
K–10	1.9E+00	4.9E–01	0.7		0.9	7.4	0.63		0.19	0.02	1.4700	0.0791	0.7434	0.0791	2.4
L–4	1.9E+00	4.9E–01		16.7		7.4		0.43		0.01	13.6753	0.0324	3.4656	0.0324	17.2
L–5	1.9E+00	4.9E–01		10.5		7.4		0.27		0.69	15.0843	2.4959	1.3625	2.4959	21.4
L–6	1.9E+00	4.9E–01				7.4				1.00	14.0600	3.5964	0.0000	3.5964	21.3
L–7	1.9E+00	4.9E–01				7.4				1.00	14.0600	3.5964	0.0000	3.5964	21.3
L–8	1.9E+00	4.9E–01				7.4				0.71	10.0248	2.5642	0.0000	2.5642	15.2
L–9	1.9E+00	4.9E–01				7.4				0.66	9.2796	2.3736	0.0000	2.3736	14.0
L–10	1.9E+00	4.9E–01				7.4				0.36	5.0616	1.2947	0.0000	1.2947	7.7
M–5	1.9E+00	4.9E–01				7.4		0.05		0.44	6.1864	1.5824	0.0000	1.5824	9.4
M–6	1.9E+00	4.9E–01				7.4				1.00	14.0600	3.5964	0.0000	3.5964	21.3
M–7	1.9E+00	4.9E–01				7.4				0.82	11.5292	2.9490	0.0000	2.9490	17.4
N–4	1.9E+00	4.9E–01		3.8				0.18			1.3140	0.0000	0.3361	0.0000	1.7
N–5	1.9E+00	4.9E–01		7.2		7.4		0.51		0.13	8.8335	0.4819	1.7776	0.4819	11.6
N–6	1.9E+00	4.9E–01		3.9		7.4		0.03		0.67	9.6070	2.4024	0.0550	2.4024	14.5
N–7	1.9E+00	4.9E–01				7.4				0.15	2.0387	0.5215	0.0000	0.5215	3.1
														Total EDE	405

Total Particulate =	326
Total Radon EDE =	78

Table 4-5 presents the baseline case for evaluating the collective EDE to the population within 50 miles of the Site. The baseline conditions are that the windblown and Malpais Exclusion Area within the exemption area are decontaminated to the limit for unrestricted release, or 5.0 pCi/g above background. This results in a calculated annual collective EDE of 444 mrem/y.

The incremental annual collective EDE to individuals within 50 miles of the Site is considered the difference between the calculated EDE and the baseline EDE, or minus 39 mrem/y. This indicates that the population will receive less EDE from surface soils within the Exemption Boundary Area than if the Ra-226 concentration in the soils were at the limit for unrestricted release.

The collective EDE of 405 person-mrem/y (0.405 person-rem/y) may be compared to the EDE that the population receives from natural background radiation. The background gamma-ray exposure rate near the Site has been measured to average 12.3 μR/h, or approximately 110 mrem/year (ARCO, 1993). If one considers the exposure to outdoor radon and radionuclide particulate from natural sources, the total individual EDE would be expected to exceed 200 mrem/y. This would result in a collective EDE for the 65,129 people of more than 13,000 person-rem/y. The additional 0.4 person-rem to the 13,000 person-rem/y from natural background for this population group is considered insignificant.

Table 4–5. Collective EDE for Population Within Fifty Miles of Site Assuming Areas Contaminated at Limit for Unrestricted Release

Grid Block	Particulate EDE mrem/y per pCi/g	Radon EDE mrem/y per pCi/g	Avg. Ra–226 (pCi/g)				Area Percentage				Particulate EDE (mrem/y)		Radon EDE (mrem/y)		Total EDE mrem/y
			Chinle	Lava	Limestone	Malpais	Chinle	Lava	Limestone	Malpais	Windblown	Malpais	Windblown	Malpais	
F–2	1.9E+00	4.9E–01				5.0				0.99	0.0000	9.3765	0.0000	2.3984	11.8
F–3	1.9E+00	4.9E–01				5.0				0.93	8.8730	2.2698	0.0000	2.2696	13.4
F–4	1.9E+00	4.9E–01				5.0				0.82	7.7710	1.9877	0.0000	1.9877	11.7
F–5	1.9E+00	4.9E–01				5.0				0.27	2.5650	0.6561	0.0000	0.6561	3.9
G–2	1.9E+00	4.9E–01				5.0				0.42	3.9900	1.0206	0.0000	1.0206	6.0
G–3	1.9E+00	4.9E–01				5.0				0.05	0.4655	0.1191	0.0000	0.1191	0.7
G–5	1.9E+00	4.9E–01				5.0	0.03			0.10	0.9405	0.2408	0.0000	0.2406	1.4
G–6	1.9E+00	4.9E–01	5.0				0.35				3.3250	0.0000	0.8505	0.0000	4.2
H–1	1.9E+00	4.9E–01		5.0				0.86			8.1700	0.0000	2.0898	0.0000	10.3
H–6	1.9E+00	4.9E–01	5.0				0.91				8.6450	0.0000	2.2113	0.0000	10.9
H–7	1.9E+00	4.9E–01	5.0				0.60				5.7000	0.0000	1.4580	0.0000	7.2
I–1	1.9E+00	4.9E–01		5.0			0.00	0.99			9.3955	0.0000	2.4033	0.0000	11.8
I–2	1.9E+00	4.9E–01		5.0				0.35			3.3535	0.0000	0.8578	0.0000	4.2
I–6	1.9E+00	4.9E–01	5.0		5.0		0.32		0.62		8.9300	0.0000	3.5167	0.0000	12.4
I–7	1.9E+00	4.9E–01	5.0		5.0		0.36		0.64		9.5000	0.0000	3.6158	0.0000	13.1
I–8	1.9E+00	4.9E–01	5.0				0.76				7.2200	0.0000	1.8468	0.0000	9.1
J–2	1.9E+00	4.9E–01		5.0				0.98			9.2910	0.0000	2.3765	0.0000	11.7
J–3	1.9E+00	4.9E–01		5.0				0.21			1.9665	0.0000	0.5030	0.0000	2.5
J–6	1.9E+00	4.9E–01			5.0				0.97		9.2530	0.0000	2.9034	0.0000	12.2
J–7	1.9E+00	4.9E–01			5.0				1.00		9.5000	0.0000	2.9160	0.0000	12.4
J–8	1.9E+00	4.9E–01	5.0		5.0		0.69		0.31		9.5285	0.0000	4.2598	0.0000	13.8
J–9	1.9E+00	4.9E–01	5.0				1.00				9.5000	0.0000	2.4300	0.0000	11.9
K–1	1.9E+00	4.9E–01		5.0				1.00			9.5000	0.0000	2.4300	0.0000	11.9
K–2	1.9E+00	4.9E–01		5.0				0.96			9.1200	0.0000	2.3328	0.0000	11.5
K–3	1.9E+00	4.9E–01		5.0				0.64			6.0800	0.0000	1.5552	0.0000	7.6
K–4	1.9E+00	4.9E–01		5.0				0.51			4.8640	0.0000	1.2442	0.0000	6.1
K–5	1.9E+00	4.9E–01		5.0		5.0		0.57		0.40	9.2245	0.9720	1.3875	0.9720	12.6
K–6	1.9E+00	4.9E–01		5.0	5.0	5.0		0.09	0.15	0.72	9.1200	1.7496	2.7216	1.7496	15.3
K–7	1.9E+00	4.9E–01			5.0	5.0			0.35	0.65	9.5095	1.5795	2.6006	1.5795	15.3
K–8	1.9E+00	4.9E–01			5.0	5.0			0.56	0.44	9.4620	1.0692	2.7002	1.0692	14.3
K–9	1.9E+00	4.9E–01	5.0		5.0	5.0	0.28		0.55	0.17	9.5000	0.4228	3.3680	0.4228	13.7
K–10	1.9E+00	4.9E–01	5.0		5.0	5.0	0.63		0.19	0.02	7.9895	0.0535	4.0547	0.0535	12.2
L–4	1.9E+00	4.9E–01		5.0		5.0		0.43		0.01	4.1420	0.0219	1.0375	0.0219	5.2
L–5	1.9E+00	4.9E–01		5.0		5.0		0.27		0.69	9.1295	1.6864	0.6488	1.6864	13.2
L–6	1.9E+00	4.9E–01				5.0				1.00	9.5000	2.4300	0.0000	2.4300	14.4
L–7	1.9E+00	4.9E–01				5.0				1.00	9.5000	2.4300	0.0000	2.4300	14.4
L–8	1.9E+00	4.9E–01				5.0				0.71	6.7735	1.7326	0.0000	1.7326	10.2
L–9	1.9E+00	4.9E–01				5.0				0.66	6.2700	1.6038	0.0000	1.6038	9.5
L–10	1.9E+00	4.9E–01				5.0				0.36	3.4200	0.8748	0.0000	0.8748	5.2
M–5	1.9E+00	4.9E–01				5.0		0.05		0.44	4.1800	1.0692	0.0000	1.0692	6.3
M–6	1.9E+00	4.9E–01				5.0				1.00	9.5000	2.4300	0.0000	2.4300	14.4
M–7	1.9E+00	4.9E–01				5.0				0.82	7.7900	1.9926	0.0000	1.9926	11.8
N–4	1.9E+00	4.9E–01		5.0				0.18			1.7290		0.4423	0.0000	2.2
N–5	1.9E+00	4.9E–01		5.0		5.0		0.51		0.13	6.0990	0.3256	1.2344	0.3256	8.0
N–6	1.9E+00	4.9E–01		5.0		5.0		0.03		0.67	6.6215	1.6232	0.0705	1.6232	9.9
N–7	1.9E+00	4.9E–01				5.0				0.15	1.3775	0.3524	0.0000	0.3524	2.1
														Total EDE	444

Total Particulate = 348

Total Radon ED[illegible] = 95

4.4 Risk to the Maximum Exposed Individual and Nearby Population

The maximum EDE to a hypothetical individual living at the Site boundary was calculated in Section 4.2 as 3.0 mrem/y above natural background from the Site. This EDE resulted from the windblown area and the Malpais Exclusion Area within the Exemption Boundary Area under its current remediated condition.

The EPA in CAP88-PC assigns a life-time risk factor of 0.0004 per rem (EDE) of exposure. If one assumes that the individual lives at the Site boundary for 70 years, then the integrated EDE would be 0.2 rem, resulting in a probability of a fatal cancer of 8×10^{-5} during his/her lifetime.

The population dose assessment presented in Section 4.3 indicated that the population within 50 miles would collectively receive an additional EDE of approximately 0.4 person-rem over a 70-year period as a result of the surface soil contamination above the cleanup criterion within the Exemption Boundary Area. Assuming that this population of 65,000 within 50 miles of the Site remains constant for 70 years, then one would expect 0.011 fatal cancers within this group over the 70-year period. Since this is an extremely small number, it is very unlikely that a fatal cancer will occur within this group.

As can be concluded from the above calculated risks, the individual risk associated with living near the Site is well within the acceptable risk range associated with environmental radioactivity and insignificant compared to the risk associated with exposure to natural background radiation sources. The collective risk to the population within 50 miles of the site is also extremely small. It is very unlikely that a fatal cancer will ever result from this very small source of radiation exposure.

5.0 COST-BENEFIT ANALYSIS

The windblown area (approximately 400 acres) within the Exemption Boundary Area has been excavated to the extent practical using standard industrial equipment. While the NRC and ARCO have agreed to this plan, ARCO requested that its reclamation contractor, Industrial Constructors Corporation (ICC), evaluate additional methods to remove the remaining windblown material. ICC indicated that an attempt to remove an additional 1-foot thick layer from the surface (minimal possible layer) could be made by using a large dozer to rip the surface and remove as much of the fractured rock as possible. The estimated cost for removing the material and placing it on the Acid Tailings Pile is estimated at $15,000 per acre. There are approximately 42 acres where the bulk average Ra-226 concentration (average concentration in the top 15 cm layer) exceeds the 6.9 pCi/g release criterion. This additional cleanup would cost approximately $630,000.

The annual collective EDE to the population within 50 miles of the Site has been calculated in Section 4.3 to be 0.4 person-rem. Considering an average life span of 70 years, the average life-long total collective EDE to the off-site population is 28 person-rem. If the additional expenditure of $630,000 resulted in no additional EDE to the off-site population, then the cost to save 1 rem would be $23,000. This may be compared to the ALARA criterion of $1,000 per man-rem saved as specified in 10 CFR 50, Appendix I.

This cost-benefit analysis confirms that the decision to request an exemption for the windblown areas within the Exemption Boundary Area is reasonable and consistent with the ALARA guidance of the NRC.

6.0 CONCLUSION

The reclamation of the windblown areas around the tailings piles at the Site has been completed consistent with the Reclamation Plan. While approximately 1,000 acres that contained windblown tailings or evaporation pond material have been remediated, it has been demonstrated to be impractical to decontaminate approximately 42 windblown tailings acres to meet the Ra-226 concentration limit for unrestricted release. Repeated attempts at cleaning some of these areas were not effective in reducing the levels further.

In order to demonstrate that the risk associated with these areas is acceptable, a dose assessment was made which showed that a hypothetical person living at the Site boundary would receive an additional EDE of 3.0 mrem/y. If the entire area within the exemption boundary were decontaminated to the unconditional release criteria (baseline case), the EDE to that individual would have been 3.4 mrem/y. This results in no incremental EDE or risk the collective EDE to the 65,000 population within 50 miles of the Site was calculated to be approximately 404 mrem/y. For the baseline case, the EDE was calculated to be 443 mrem/y. The EDE to the maximum exposed individual as well as to the population is insignificant compared to the regulatory limits as well as that received from natural background sources.

A cost-benefit analysis indicates that in order to decontaminate the areas to meet the unconditional release criteria would cost an additional $630,000 or $23,000 per person-rem, assuming a 70-year exposure time. This is 23 times the NRC ALARA criterion of $1,000 per person rem. Therefore additional efforts to remediate the area are clearly not warranted.

This exemption request presents a practical approach that provides health protection for the public and results in a safe and cost-effective remedial action.

REFERENCES

ARCO, 1989. Final Socioeconomic Report for Bluewater Uranium Mill Vicinity, prepared by Dames & Moore, 1626 Cole Boulevard, Golden, CO 80401, August 4, 1989.

ARCO, 1990 Reclamation Plan-Bluewater Mill Reclamation Plan, prepared by ARCO Coal Company, P. O. Box 638, Grants, NM 87020, March 1990.

ARCO, 1992. Windblown Contamination Cleanup Report, Atlantic Richfield Company, Bluewater Mill, P. O. Box 628, Grants, New Mexico 87020, October 30, 1992.

ARCO, 1993. Supplement to Environmental Report for the Decommissioning and Reclamation of the Bluewater Uranium Mill, prepared by Environmental Restoration Group, Inc., 12809 Arroyo de Vista NE, Albuquerque, NM 87111, April 7, 1993.

CENSUS, 1990. General Population Characteristics, New Mexico, U. S. Department of Commerce, Bureau of Census, 1992.

EPA, 1993. Technical Support For Amending Standards For Management of Uranium Byproduct Materials, 40 CFR Part 192 Subpart D, Draft-Background Information Document, EPA 402-D-93-001, May 1993, United States Environmental Protection Agency.

EPA, 1992. User's Guide for CAP88-PC, Version 1, EPA 402-B-92-001, March 1992, United States Environmental Protection Agency, Office of Radiation Programs, Las Vegas Facility, P. O. Box 98517, Las Vegas, NV 89193-8517.

Gonzales, 1994. Gonzales, D. E., Millard, J. B., Miller, M.L., and D. Metzler. "Cleanup Protocol for ^{226}Ra-Contaminated Cobbly Soil at UMTRA Project Sites." Health Physics 66, No.1, p.80, January 1994.

Appendix A

Surface Soil Sample Verification Data for the Exemption Boundary Area

ARCO Bluewater Mill
Soil Sample Results

Sample ID #	Description	Ra - 226 Content (pCi/gm) Soil	Bulk Average
Grid Block H1			
93-3594S	H1-24-11	3.5	3.3
93-2699S	H1-24-26	3.6	3.3
93-2699S	H1-24-29	2.9	2.9
	Average	3.3	3.2
Grid Block I1			
93-6433	I1-5-11	4.4	3.7
93-2799	I1-5-26	3.6	3.3
93-2788S	I1-10-8	3.1	3.0
93-2789S	I1-10-11	31.5	18.1
93-6415	I1-10-29	3.1	3.1
	Average	9.1	6.2
Grid Block I2			
93-2757S	I2-6-11	1.3	2.1
93-2752S	I2-6-26	3.4	3.2
93-2759S	I2-6-29	4.2	3.6
93-2676S	I2-11-8	1.2	2.0
93-2677S	I2-11-11	8.5	4.9
93-2678S	I2-11-26	4.9	4.0
93-2679S	I2-11-29	4.7	3.9
93-2711S	I2-12-11	2.1	2.5
93-2712S	I2-12-26	1.8	2.2
93-2713S	I2-12-29	2.9	3.0
93-6485	I2-16-8	1.7	2.3
93-6475	I2-16-11	2.9	2.9
93-6485	I2-16-29	3.1	3.1
93-2781S	I2-17-8	2.1	2.5
93-2782S	I2-17-11	4.5	3.8
93-2783S	I2-17-26	2.2	2.6
93-2784S	I2-17-29	1.5	2.2
93-2715S	I2-18-11	1.2	2.0
93-2716S	I2-18-26	1.3	2.1
93-2717S	I2-18-29	2.1	2.5
93-6315	I2-22-8	1.4	2.2
93-7325	I2-23-8	1.9	2.4
93-7335	I2-23-11	1.1	2.0
93-7345	I2-23-26	0.2	1.5
93-7355	I2-23-29	1.3	2.1
93-6295	I2-24-26	5.5	4.3
	Average	2.8	2.8
Grid Block J2			
93-7125	J2-3-8	1.1	2.0
93-7135	J2-3-11	1.2	2.1
93-7145	J2-3-26	1.7	2.3
93-7155	J2-3-29	1.2	2.0
93-5925	J2-4-8	1.1	2.0
93-5935	J2-4-11	1.4	2.1
93-5945	J2-4-26	1.2	2.0
93-5955	J2-4-29	3.9	3.5
93-6045	J2-5-26	4.3	3.7
93-6545	J2-6-11	5.5	4.3
93-6555	J2-6-26	3.3	3.2
93-6565	J2-6-29	5.8	4.5
93-6933	J2-8-8	1.7	2.3
93-3505	J2-9-8	0.9	1.9
93-6515	J2-9-11	0.4	1.6
93-6525	J2-9-29	0.9	1.9
93-7275	J2-10-8	4.5	3.8
93-7285	J2-10-11	1.8	2.4
93-7295	J2-10-26	1.3	2.1
93-7305	J2-10-29	2.4	2.7
93-6375	J2-14-8	1.3	2.1
93-6385	J2-14-29	1.1	2.0
93-6675	J2-15-8	0.9	1.9
93-6685	J2-15-11	1.2	2.0
93-6695	J2-15-26	1.3	2.1
93-6705	J2-15-29	1.8	2.2
93-6725	J2-20-8	1.4	2.1
93-6735	J2-20-11	1.1	2.0
93-6745	J2-20-26	1.3	2.1
93-6755	J2-20-29	1.5	2.2
93-6775	J2-25-8	6.0	4.8
93-6785	J2-25-11	4.7	3.9
93-6795	J2-25-26	2.0	2.5
93-6805	J2-25-29	4.3	3.7
	Average	2.2	2.6
Grid Block K1			
93-11275	K1-19-8	1.5	2.2
93-11285	K1-19-26	1.7	2.3
93-11295	K1-19-29	1.1	2.0
93-11785	K1-20-8	1.7	2.3
93-11795	K1-20-26	1.0	1.9
93-11805	K1-20-29	1.1	2.0
93-10905	K1-24-8	1.1	2.0
93-10915	K1-24-11	1.0	1.9
93-10925	K1-24-26	1.3	2.1
93-10935	K1-24-29	0.9	1.9
93-10855	K1-25-8	1.3	2.1
93-10865	K1-25-11	0.8	1.9
93-10875	K1-25-26	0.7	1.8
93-10885	K1-25-29	1.0	2.0
	Average	1.2	2.0

ARCO Bluewater Mill
Soil Sample Results

Sample ID #	Description	Ra-226 Content (pCi/gm) Soil	Bulk Average
Grid Block K2			
93-33805	K2-3-11	6.8	5.0
93-33795	K2-3-26	7.6	5.4
93-33825	K2-3-29	2.7	2.8
93-12515	K2-5-8	2.2	2.5
93-12545	K2-5-11	5.8	4.5
93-12555	K2-5-26	5.3	4.2
93-12565	K2-5-29	2.7	2.8
93-31765	K2-6-26	2.4	2.7
93-35825	K2-6-29	4.8	3.8
93-35805	K2-7-26	4.1	3.6
93-12455	K2-10-8	9.4	6.4
93-12465	K2-10-11	9.2	5.7
93-12475	K2-10-29	10	6.7
93-35835	K2-11-6	4.1	3.6
93-31735	K2-11-11	1.3	2.1
93-31745	K2-11-29	1.5	2.2
93-27195	K2-13-8	11.2	7.3
93-27205	K2-13-26	3.1	3.0
93-27215	K2-13-29	6.0	4.8
93-12445	K2-14-29	4.0	3.5
93-12085	K2-15-11	9.9	6.6
93-11975	K2-16-8	2.1	2.5
93-11985	K2-16-11	1.4	2.2
93-11995	K2-16-26	1.2	2.1
93-12005	K2-16-29	1.1	2.0
93-27425	K2-17-8	2.3	2.6
93-30495	K2-17-11	1.4	2.2
93-27435	K2-17-26	1.5	2.2
93-27445	K2-17-29	1.3	2.1
93-27715	K2-18-8	2.4	2.7
93-28155	K2-18-11	2.0	2.4
93-28165	K2-18-26	2.3	2.6
93-28175	K2-18-29	1.9	2.4
93-27705	K2-19-8	2.9	2.9
93-12035	K2-19-11	5.0	4.0
93-12045	K2-19-26	2.9	2.9
93-12055	K2-19-29	2.6	2.6
93-11945	K2-20-26	3.8	3.4
93-10955	K2-21-8	1.3	2.1
93-10965	K2-21-11	1.2	2.0
93-10975	K2-21-26	1.0	1.9
93-10985	K2-21-29	1.0	1.9
93-10755	K2-22-8	1.0	1.9
93-10765	K2-22-11	1.1	2.0
93-10775	K2-22-26	1.6	2.4
93-10785	K2-22-29	1.7	2.3
93-10805	K2-23-8	0.9	1.9
93-10815	K2-23-11	1.7	2.3
93-10825	K2-23-26	4.6	3.8
93-10835	K2-23-29	2.9	2.9
93-11335	K2-24-8	1.3	2.1
93-11345	K2-24-11	1.4	2.2
93-11355	K2-24-26	0.9	1.8
93-11365	K2-24-29	2.1	2.5
93-11005	K2-25-8	2.1	2.5
93-11015	K2-25-11	1.2	2.1
93-11025	K2-25-26	2.5	2.7
93-11035	K2-25-29	1.5	2.2
	Average	3.2	3.1
Grid Block K3			
93-27905	K3-1-8	3.2	3.1
93-27915	K3-1-11	7.7	5.5
93-7085	K3-1-26	22.0	13.1
93-27925	K3-1-29	6.7	4.9
93-27645	K3-2-8	8.2	5.7
93-7035	K3-2-11	3.5	3.3
93-27665	K3-2-26	7.4	5.3
93-27675	K3-2-29	1.1	2.0
93-27305	K3-3-8	3.0	3.0
93-27315	K3-3-11	3.6	2.8
93-27325	K3-3-26	1.5	2.2
93-27385	K3-4-11	2.6	2.8
93-27375	K3-4-26	5.8	4.5
93-27385	K3-4-29	4.2	3.6
93-8055	K3-5-8	16.2	11.0
93-8045	K3-5-11	5.2	4.2
93-8055	K3-5-26	39.2	22.2
93-8065	K3-5-29	45.3	25.4
93-27455	K3-6-8	5.0	4.0
93-27475	K3-6-26	2.4	2.7
93-28075	K3-7-8	4.9	4.0
93-28085	K3-7-11	2.1	2.5
93-28095	K3-7-26	4.5	3.8
93-28105	K3-7-29	1.6	2.3
93-27535	K3-8-8	1.8	2.3
93-27545	K3-8-11	0.8	1.8
93-27555	K3-8-26	4.7	3.9
93-7575	K3-9-8	20.1	12.0
93-7585	K3-9-11	9.3	6.3
93-7595	K3-9-26	4.0	3.5
93-7655	K3-10-8	18.0	10.9
93-7675	K3-10-26	14.0	8.8
93-28185	K3-10-29	1.9	2.4
93-27515	K3-12-8	11.1	7.3
93-27525	K3-12-11	2.5	2.7
93-12175	K3-12-29	66.2	36.5
93-12400	K3-13-8	6.0	4.6
93-12415	K3-13-11	62.4	34.5
93-12425	K3-13-26	17.3	10.6
93-12435	K3-13-29	6.3	4.7
93-12235	K3-14-8	9.9	6.7
93-12245	K3-14-11	38.9	22.0
93-12255	K3-14-26	31.2	17.9
93-12265	K3-14-29	22.5	13.3
93-27275	K3-15-8	13.7	8.7
93-27285	K3-15-11	6.7	4.0
93-27295	K3-15-26	0.7	1.8
93-12215	K3-15-29	44.7	25.1
93-11625	K3-18-11	0.7	1.8
93-11275	K3-21-11	1.1	2.0
93-11285	K3-21-26	0.9	1.9
93-11295	K3-21-29	1.9	2.4
	Average	12.1	7.8

ARCO Bluewater Mill
Soil Sample Results

Sample ID #	Description	Ra-226 Content (pCi/gm) Soil	Bulk Average
		Grid Block K4	
93-8075	K4-1-8	2.0	2.5
93-8085	K4-1-11	2.7	2.8
93-8095	K4-1-26	26.1	15.3
93-8105	K4-1-29	25.6	15.0
93-10585	K4-3-29	1.6	2.3
93-10585	K4-4-26	1.1	2.0
93-10595	K4-4-29	2.3	2.6
93-10605	K4-5-26	1.4	2.2
93-10615	K4-5-29	3.7	3.4
93-7685	K4-6-8	22.8	13.5
93-7705	K4-6-11	30.1	17.4
93-7715	K4-6-26	13.8	8.7
93-7725	K4-6-29	8.6	5.9
93-27335	K4-7-8	1.5	2.2
93-27345	K4-7-11	1.4	2.2
93-7835	K4-7-26	15.6	9.7
93-27335	K4-7-29	1.2	2.0
93-28035	K4-8-8	3.9	3.5
93-28045	K4-8-11	6.7	4.9
93-28055	K4-8-26	2.4	2.6
93-28065	K4-8-29	2.5	2.7
93-27065	K4-9-11	2.5	2.7
93-27075	K4-9-26	2.1	2.5
93-27085	K4-9-29	5.3	4.2
94-00215	K4-10-8	2.7	2.8
94-0225	K4-10-11	0.5	1.7
94-00235	K4-10-26	3.1	3.0
94-00245	K4-10-29	2.5	2.7
93-12335	K4-11-8	3.0	3.0
93-12345	K4-11-11	2.2	2.5
93-12125	K4-12-8	209.5	112.4
93-12135	K4-12-11	3.8	3.4
93-12365	K4-13-11	45.1	25.3
93-35875	K4-15-11	9.3	6.3
93-35885	K4-15-26	15.9	9.8
93-35865	K4-15-29	14.6	8.1
	Average	13.9	8.7
		Grid Block K5	
93-10675	K5-1-8	1.2	2.0
93-10685	K5-1-11	0.9	1.9
93-27295	K5-1-26	6.0	4.6
93-27245	K5-1-29	8.9	6.6
93-10275	K5-2-8	1.3	2.1
93-10285	K5-2-11	1.0	1.9
93-28115	K5-2-26	2.3	2.8
93-28125	K5-2-29	3.9	3.5
93-28145	K5-3-26	4.1	3.6
93-28135	K5-3-29	1.9	2.4
93-27485	K5-6-8	1.5	2.2
93-27505	K5-6-11	4.8	3.9
93-5675	K5-7-8	6.2	4.7
93-27385	K5-7-11	1.9	2.4
93-27[illegible]	K5-7-26	0.8	1.8
93-27415	K5-7-29	4.0	3.5
93-5795	K5-8-8	6.6	4.9
93-5805	K5-8-11	4.3	3.7
93-5815	K5-8-26	7.2	5.2
93-5825	K5-8-29	2.4	2.7
93-36445	K5-9-8	3.5	3.3
93-36455	K5-9-11	4.4	3.7
93-36465	K5-9-26	4.1	3.6
93-36475	K5-9-29	3.3	3.1
93-5455	K5-10-8	4.4	3.7
93-5465	K5-10-11	10.5	7.0
93-5475	K5-10-26	4.3	3.7
93-5485	K5-10-29	1.8	2.4
93-35685	K5-11-8	3.4	3.2
93-35915	K5-11-29	17.1	10.5
93-5535	K5-12-8	3.3	3.1
93-27875	K5-12-11	3.8	3.5
93-27985	K5-12-26	6.2	5.8
93-5565	K5-12-29	5.9	4.5
93-29005	K5-13-8	6.3	5.8
93-5595	K5-13-11	7.1	5.2
93-5605	K5-13-26	3.5	3.2
93-29015	K5-13-29	5.6	4.4
93-27855	K5-14-8	5.7	4.4
93-34455	K5-14-11	5.3	4.2
93-34465	K5-14-26	7.2	5.2
93-34475	K5-14-29	8.2	5.9
93-34355	K5-15-8	4.2	3.6
93-34365	K5-15-11	3.0	3.0
93-34375	K5-15-26	1.3	2.1
93-34385	K5-15-29	11.3	7.1
	Average	4.8	3.9
		Grid Block K6	
93-9525	K6-2-8	7.8	4.1
93-33735	K6-2-11	29.2	11.2
93-33745	K6-2-26	37.8	16.1
93-33755	K6-2-29	37.3	16.0
93-9475	K6-3-8	13.8	6.8
93-9485	K6-3-11	8.5	4.4
93-9495	K6-3-26	9.9	5.1
93-9505	K6-3-29	1.6	1.2
93-31945	K6-4-8	1.5	1.1
93-31955	K6-4-29	1.6	1.2
93-9115	K6-5-8	29.4	13.8
93-9125	K6-5-11	20.3	10.0
93-9135	K6-5-26	1.4	1.1
93-9145	K6-5-29	2.0	1.3
93-5485	K6-6-8	19.9	11.9
93-5505	K6-6-11	2.9	2.9
93-5515	K6-6-26	1.5	2.2
93-5525	K6-6-29	3.1	3.1
93-34405	K6-11-8	5.9	4.5
93-34415	K6-11-11	1.6	2.3
93-34425	K6-11-26	5.6	4.4
	Average	11.2	6.1

ARCO Bluewater Mill
Soil Sample Results

Sample ID #	Description	Ra - 226 Content (pCi/gm) Soil	Bulk Average
		Grid Block K7	
93-9075	K7-1-11	12.5	6.3
93-9085	K7-1-26	1.4	1.1
93-9095	K7-1-29	1.8	1.3
93-8965	K7-2-8	1.4	1.1
93-9685	K7-2-26	1.7	1.2
93-9675	K7-2-29	1.2	1.0
92-6515	K7-5-8	5.2	2.8
92-6525	K7-5-11	6.4	3.4
92-6535	K7-5-26	8.1	4.2
92-6545	K7-5-29	7.9	4.1
93-8925	K7-8-8	2.3	1.5
93-8935	K7-8-11	1.6	1.1
93-8945	K7-8-26	1.9	1.3
93-8975	K7-9-8	2.3	1.5
93-8985	K7-9-11	3.0	1.8
93-8995	K7-9-26	2.5	1.6
93-8905	K7-9-29	1.7	1.2
93-9825	K7-10-8	2.3	1.5
93-9835	K7-10-11	1.7	1.2
93-9845	K7-10-26	2.4	1.5
93-9855	K7-10-29	1.4	1.0
93-9565	K7-14-8	1.7	1.2
93-9575	K7-14-11	2.3	1.5
93-9805	K7-15-8	2.5	1.6
93-9815	K7-15-11	1.9	1.3
	Average	3.2	1.9
		Grid Block K8	
92-6275	K8-1-8	1.0	1.1
93-34585	K8-1-11	2.6	1.6
92-6295	K8-1-26	7.8	4.1
92-6305	K8-1-29	3.3	2.0
92-3865	K8-2-8	8.0	4.2
92-3875	K8-2-11	3.3	2.0
92-3885	K8-2-26	8.3	4.3
92-3895	K8-2-29	4.2	2.4
92-4655	K8-3-8	2.8	1.7
92-4665	K8-3-11	1.9	1.3
92-4675	K8-3-26	2.8	1.6
92-4685	K8-3-29	2.9	1.8
92-4465	K8-4-8	2.5	1.6
92-4475	K8-4-11	5.8	3.1
92-4485	K8-4-26	1.9	1.3
92-4495	K8-4-29	1.7	1.2
92-3645	K8-5-8	1.5	1.1
92-3655	K8-5-11	1.9	1.3
92-3665	K8-5-26	4.6	2.6
92-3675	K8-5-29	3.2	1.9
92-6435	K8-6-8	3.3	2.0
92-6445	K8-6-11	0.8	0.8
92-6455	K8-6-26	2.0	1.3
92-6465	K8-6-29	0.0	0.4
92-4735	K8-7-8	8.5	4.4
92-4745	K8-7-11	0.4	0.6
92-4755	K8-7-26	1.1	0.9
92-4765	K8-7-29	1.2	1.0
92-4695	K8-8-8	1.2	1.0
92-4705	K8-8-11	3.2	1.9
92-4715	K8-8-26	6.8	3.6
92-4725	K8-8-29	-1.3	-0.2
92-4235	K8-9-8	3.1	1.9
92-4245	K8-9-11	7.6	4.0
92-4255	K8-9-26	0.1	0.4
92-4265	K8-9-29	2.9	1.8
92-3825	K8-10-8	2.1	1.4
92-3835	K8-10-11	5.8	3.1
92-3845	K8-10-26	2.5	1.6
92-3855	K8-10-29	3.5	2.0
93-9625	K8-11-8	2.6	1.8
93-9635	K8-11-11	2.3	1.5
93-36715	K8-12-8	2.6	1.6
93-36725	K8-12-11	1.6	1.1
93-9265	K8-13-8	4.5	2.5
93-9275	K8-13-11	1.4	1.0
93-9285	K8-13-26	1.3	1.0
93-9295	K8-13-29	1.9	1.3
92-4365	K8-14-8	3.1	1.9
92-4375	K8-14-11	1.8	1.2
92-4385	K8-14-26	2.9	1.7
92-4395	K8-14-29	5.4	2.9
92-3785	K8-15-8	-0.6	0.1
92-3795	K8-15-11	3.8	2.2
92-3805	K8-15-26	3.2	1.9
92-3815	K8-15-29	5.4	2.9
	Average	3.0	1.8

ARCO Bluewater Mill
Soil Sample Results

Sample ID #	Description	Ra -226 Content (pCi/gm) Soil	Bulk Average
		Grid Block K9	
92-4065	K9-1-8	3.4	2.6
92-4105	K9-1-11	2.0	1.6
92-4115	K9-1-26	3.6	2.1
92-4125	K9-1-29	2.4	1.5
92-3945	K9-2-8	3.2	2.7
92-3955	K9-2-11	3.3	2.8
92-3965	K9-2-26	2.3	2.0
92-3975	K9-2-29	1.3	1.3
92-9075	K9-3-8	4.5	3.6
92-9085	K9-3-11	1.6	1.5
92-9095	K9-3-26	3.1	2.6
92-9405	K9-3-29	2.1	1.9
93-11915	K9-4-11	1.8	1.7
93-11925	K9-4-26	3.1	2.6
92-4145	K9-5-8	2.2	1.4
92-4155	K9-5-11	4.5	2.5
92-4165	K9-5-26	4.0	2.3
92-4175	K9-5-29	2.4	1.5
92-4045	K9-7-8	2.0	1.3
92-4055	K9-7-11	4.6	2.6
92-4065	K9-7-26	2.2	1.4
92-4075	K9-7-29	-1.2	-0.2
92-4325	K9-8-8	4.8	3.8
92-4335	K9-8-11	1.4	1.0
92-4345	K9-8-26	4.1	2.3
92-4355	K9-8-29	9.3	4.8
93-9435	K9-9-8	4.8	3.8
93-9445	K9-9-11	4.5	3.6
93-9455	K9-9-26	2.2	1.5
93-9465	K9-9-29	4.1	3.3
92-4185	K9-11-8	1.8	1.3
92-4195	K9-11-11	3.3	2.0
92-8435	K9-11-26	1.0	0.9
92-4215	K9-11-29	7.6	4.0
92-4415	K9-12-8	3.1	1.9
92-4425	K9-12-11	1.7	1.2
92-4435	K9-12-26	2.0	1.4
92-4445	K9-12-29	0.2	0.5
92-4275	K9-13-8	4.2	2.4
92-4285	K9-13-11	2.2	1.4
92-4295	K9-13-26	0.1	0.5
92-4305	K9-13-29	2.0	1.3
93-0445	K9-14-8	2.6	1.7
93-0455	K9-14-11	4.3	2.4
93-0465	K9-14-26	8.5	4.4
93-0565	K9-15-8	2.8	2.4
93-0575	K9-15-11	3.7	2.1
93-10055	K9-17-8	1.9	1.3
93-10065	K9-17-11	2.7	1.7
93-10075	K9-17-26	9.5	4.9
93-9645	K9-18-8	5.4	3.0
93-9655	K9-18-11	2.5	1.6
93-11685	K9-18-8	2.7	1.7
	Average	3.2	2.1

ARCO Bluewater Mill
Soil Sample Results

Sample ID #	Description	Ra-226 Content (pCi/gm) Soil	Bulk Average
		Grid Block K10	
93-10235	K10-3-8	3.4	2.8
93-10245	K10-3-29	4.0	3.2
93-36665	K10-8-8	3.0	2.5
93-36675	K10-8-11	3.4	2.8
93-36685	K10-8-26	2.9	2.5
93-36695	K10-8-29	1.9	1.8
93-0525	K10-11-8	2.2	2.0
93-0535	K10-11-11	1.4	1.4
93-0545	K10-11-29	5.0	4.0
93-0395	K10-12-8	3.8	3.1
93-0405	K10-12-11	1.6	1.5
93-0415	K10-12-26	3.4	2.9
93-0425	K10-12-29	5.1	4.0
93-0475	K10-13-8	3.3	2.8
93-0485	K10-13-11	4.3	3.5
93-0495	K10-13-26	6.3	4.9
93-0505	K10-13-29	4.0	3.2
93-1075	K10-14-8	2.5	2.2
93-1085	K10-14-11	3.6	2.9
93-1095	K10-14-26	2.9	2.5
93-1105	K10-14-29	3.9	3.2
93-1035	K10-15-8	1.8	1.6
93-1045	K10-15-11	4.2	3.4
93-1055	K10-15-26	2.4	2.1
93-1065	K10-15-29	2.1	1.9
93-1115	K10-19-8	2.0	1.8
93-1125	K10-19-11	2.8	2.4
93-1135	K10-19-29	2.4	2.1
93-1155	K10-20-8	2.6	2.2
93-1165	K10-20-11	1.3	1.3
93-1175	K10-20-26	3.0	2.6
93-1185	K10-20-29	2.9	2.5
	Average	3.1	2.6

ARCO Bluewater Mill
Soil Sample Results

Sample ID#	Description	Ra-226 Content (pCi/gm) Soil	Bulk Average
		Grid Block H6	
93-35555	H6-1-8	1.6	1.5
93-35565	H6-1-29	8.3	6.3
93-34195	H6-2-8	3.0	2.5
93-34205	H6-2-11	2.1	1.9
93-34215	H6-2-26	1.5	1.5
92-6915	H6-2-29	3.1	2.6
93-34275	H6-3-8	1.2	1.2
93-34285	H6-3-11	2.2	2.0
93-34275	H6-3-26	1.2	1.3
93-34295	H6-3-29	3.0	2.6
92-12145	H6-4-8	25.8	18.8
92-12155	H6-4-11	12.0	9.0
93-34035	H6-4-26	2.6	2.2
92-12175	H6-4-29	3.1	2.6
93-24825	H6-5-8	2.4	2.1
93-24835	H6-5-11	4.4	3.5
93-24845	H6-5-26	23.3	18.9
93-24855	H6-5-29	6.6	5.1
93-35535	H6-6-8	1.8	1.7
93-35545	H6-6-29	2.9	2.5
93-34085	H6-7-8	4.1	3.3
93-34105	H6-7-11	3.7	3.0
93-34115	H6-7-26	2.6	2.2
93-34125	H6-7-29	2.9	2.5
93-33845	H6-8-8	5.6	4.3
93-33855	H6-8-11	6.1	4.7
93-33865	H6-8-26	2.6	2.2
93-33875	H6-8-29	2.0	1.8
93-34255	H6-9-8	1.4	1.4
92-7635	H6-9-11	5.9	4.6
93-34235	H6-9-26	2.2	1.9
93-34245	H6-9-29	1.3	1.3
92-12185	H6-10-8	13.0	9.6
92-12195	H6-10-11	8.1	6.1
93-34345	H6-10-26	3.5	2.9
92-12215	H6-10-29	0.8	1.0
93-35465	H6-11-8	2.7	2.3
93-35475	H6-11-29	2.4	2.1
93-35485	H6-12-8	2.4	2.1
93-35505	H6-12-11	2.5	2.2
93-35515	H6-12-26	1.7	1.6
93-35525	H6-12-29	11.3	8.4
93-34045	H6-13-8	3.4	2.8
93-34055	H6-13-11	1.5	1.4
93-34065	H6-13-26	3.8	3.0
93-34075	H6-13-29	2.8	2.4
93-33885	H6-14-8	1.8	1.7
93-33895	H6-14-11	2.3	2.0
93-33905	H6-14-26	2.5	2.1
93-33915	H6-14-29	2.0	1.8
92-7575	H6-15-8	4.8	3.8
92-7585	H6-15-11	23.4	17.0
92-7595	H6-15-26	10.8	8.2
92-7605	H6-15-29	34.7	25.0
93-35355	H6-16-8	1.6	1.5
93-35365	H6-16-26	1.8	1.5
93-35375	H6-16-29	36.7	26.3
93-35395	H6-17-8	1.7	1.6
93-35405	H6-17-11	1.4	1.4
93-35415	H6-17-26	3.1	2.6
92-7225	H6-17-29	9.1	6.9
93-35425	H6-18-8	2.4	2.1
92-6815	H6-18-11	6.6	5.1
93-35435	H6-18-26	4.5	3.6
93-35445	H6-18-29	1.7	1.6
93-33905	H6-19-8	2.1	1.9
93-33945	H6-19-11	2.4	2.1
93-33955	H6-19-26	1.6	1.5
93-33965	H6-19-29	4.3	3.4
93-34295	H6-20-8	1.6	1.5
93-34305	H6-20-11	1.8	1.7
93-34005	H6-20-26	1.8	1.5
93-34325	H6-20-29	2.2	1.9
93-35525	H6-21-8	2.6	2.2
93-35335	H6-21-11	1.7	1.6
93-35345	H6-21-26	7.7	5.9
93-33605	H6-23-8	2.8	2.4
93-33615	H6-23-11	3.6	3.0
93-33625	H6-23-26	5.4	4.2
93-33035	H6-23-29	6.6	5.1
93-33555	H6-24-8	1.9	1.7
93-33565	H6-24-11	4.0	3.2
93-33575	H6-24-26	3.2	2.6
93-33585	H6-24-29	2.5	2.2
93-34145	H6-25-8	1.3	1.4
93-34155	H6-25-11	1.3	1.3
92-8645	H6-25-26	1.1	1.2
93-34175	H6-25-29	18.5	13.5
	Average	5.1	4.0

ARCO Bluewater Mill
Soil Sample Results

Sample ID#	Description	Ra -226 Content (pCi/gm) Soil	Bulk Average
93-35205	16-1-8	9.1	6.8
93-35235	16-1-11	2.7	2.3
93-35245	16-2-8	22.3	16.2
93-35255	16-2-11	8.3	6.3
93-35265	16-2-26	7.8	6.0
93-35275	16-2-29	17.1	12.6
93-33675	16-3-8	8.2	6.2
93-33685	16-3-11	6.3	4.8
93-33695	16-3-26	3.3	2.7
93-33705	16-3-29	2.4	2.1
93-33465	16-4-8	1.4	1.4
93-33475	16-4-11	2.3	2.0
93-33485	16-4-26	2.2	2.0
93-33495	16-4-29	1.3	1.3
92-7445	16-5-8	0.7	0.9
92-7455	16-5-11	2.2	2.0
92-7465	16-5-26	3.9	3.2
92-7475	16-5-29	4.3	3.5
93-35185	16-6-8	22.8	16.4
93-35195	16-6-11	2.8	2.3
93-35205	16-6-26	2.7	2.3
93-35215	16-6-29	21.1	15.4
93-35285	16-7-8	4.5	3.6
93-35295	16-7-11	15.3	11.2
93-35305	16-7-26	35.6	25.7
93-35315	16-7-29	1.5	1.4
93-33645	16-8-8	2.8	1.7
93-33655	16-8-29	6.2	3.3
93-33515	16-9-8	1.1	0.9
93-33525	16-9-11	1.4	1.1
93-33535	16-9-26	1.6	1.1
93-33545	16-9-29	1.7	1.2
92-7395	16-10-8	3.8	3.1
92-7405	16-10-11	1.2	1.0
92-7415	16-10-26	-1.1	-0.1
92-7425	16-10-29	3.4	2.0
93-35145	16-11-8	15.7	11.6
93-35155	16-11-11	6.9	5.3
93-35165	16-11-29	56.8	42.2
93-32025	16-12-8	5.2	2.8
93-32035	16-12-11	9.8	7.4
93-32045	16-12-26	4.9	2.7
93-32055	16-12-29	5.0	2.8
93-31770	16-13-8	1.1	0.9
93-31785	16-13-11	10.7	5.4
93-31795	16-13-26	4.5	2.5
93-31805	16-13-29	35.7	17.2
93-31975	16-14-8	4.9	2.7
93-31985	16-14-11	0.9	0.9
93-31995	16-14-26	13.2	6.6
93-32005	16-14-29	1.4	1.1
92-8485	16-15-8	9.4	4.8
92-8495	16-15-11	8.4	4.2
92-8505	16-15-26	5.9	3.2
92-8515	16-15-29	2.7	1.7
93-30205	16-16-8	1.1	0.9
92-8555	16-17-8	127.0	60.1
93-29555	16-17-11	0.8	0.8
92-29565	16-17-26	4.2	2.4
93-29575	16-17-29	8.3	4.3
92-8595	16-18-8	35.2	17.0
93-29825	16-18-11	10.4	5.3
93-29835	16-18-26	3.3	2.0
93-29845	16-18-29	29.2	14.1
92-8615	16-19-8	33.3	15.1
92-8625	16-19-11	44.9	21.5
92-8635	16-19-26	3.5	2.0
92-8645	16-19-29	0.4	0.6
92-5655	16-20-8	41.9	20.1
92-5665	16-20-11	4.4	2.4
92-5675	16-20-26	4.1	2.3
92-5685	16-20-29	6.9	3.6
93-30055	16-22-8	28.7	13.9
93-30065	16-22-11	3.5	2.0
93-30075	16-22-26	4.7	2.6
92-6085	16-22-29	36.7	17.7
93-29775	16-23-8	4.5	2.5
93-29785	16-23-11	13.9	6.9
93-29795	16-23-26	1.5	1.1
93-29805	16-23-29	5.9	3.2
92-5895	16-24-8	5.4	2.9
92-5905	16-24-11	8.2	4.2
92-5915	16-24-26	10.4	5.3
92-5925	16-24-29	5.7	3.1
92-5775	16-25-8	5.8	3.1
92-5785	16-25-11	3.4	2.0
92-5795	16-25-26	3.3	1.9
92-5805	16-25-29	6.9	3.8
	Average	10.8	6.3

Grid Block I8

ARCO Bluewater Mill
Soil Sample Results

Sample ID #	Description	Ra -226 Content (pCi/gm) Soil	Bulk Average
Grid Block I7			
92-8585	I7-1-8	2.7	2.3
92-8595	I7-1-11	5.7	4.4
92-8605	I7-1-26	6.4	4.9
92-8615	I7-1-29	0.9	1.0
92-8715	I7-2-8	4.4	3.5
92-8725	I7-2-11	6.2	4.8
92-8735	I7-2-26	3.2	2.7
92-8745	I7-2-29	7.9	6.0
92-7795	I7-3-8	2.8	2.4
92-7805	I7-3-11	4.8	3.8
92-7815	I7-3-26	2.1	1.9
92-7825	I7-3-29	0.8	1.0
92-10215	I7-4-8	0.6	0.8
92-10225	I7-4-11	2.2	1.9
92-10235	I7-4-26	2.5	2.2
92-10245	I7-4-29	5.0	4.0
92-12265	I7-5-8	3.2	2.6
92-12275	I7-5-11	1.9	1.7
92-12285	I7-5-26	3.6	3.0
92-12295	I7-5-29	3.3	2.8
92-9575	I7-6-8	3.5	2.9
92-9585	I7-6-11	8.3	4.3
92-9595	I7-6-26	4.8	2.7
92-9705	I7-6-29	4.9	2.7
92-8015	I7-7-8	1.7	1.2
92-8825	I7-7-11	5.8	3.1
92-8835	I7-7-26	9.1	4.7
92-8945	I7-7-29	7.1	3.7
92-7895	I7-8-8	2.2	1.4
92-7905	I7-8-11	1.8	1.2
92-7915	I7-8-26	2.3	1.5
92-7925	I7-8-29	1.0	0.9
92-7845	I7-9-8	7.1	5.5
92-7855	I7-9-11	5.0	3.9
92-7865	I7-9-26	1.0	0.9
92-7875	I7-9-29	2.0	1.8
92-9255	I7-10-8	1.4	1.4
92-9265	I7-10-11	4.2	3.4
92-9275	I7-10-26	2.7	2.3
92-9285	I7-10-29	5.6	4.4
92-8765	I7-11-8	7.9	4.1
92-8775	I7-11-11	7.5	3.9
92-8785	I7-11-26	9.5	4.9
92-8795	I7-11-29	7.3	3.9
92-4555	I7-12-8	4.3	2.4
92-4565	I7-12-11	3.8	2.2
92-4575	I7-12-26	1.8	1.3
92-4585	I7-12-29	11.2	5.7
93-6295	I7-13-8	5.8	3.1
92-7955	I7-13-11	6.6	3.5
92-7965	I7-13-26	5.9	3.2
92-7975	I7-13-29	7.4	3.9
92-4605	I7-14-8	2.8	1.6
92-4615	I7-14-11	2.2	1.5
92-4625	I7-14-26	-0.7	0.1
92-4635	I7-14-29	0.6	0.7
92-9115	I7-15-8	4.0	3.3
92-9125	I7-15-11	4.5	3.8
92-9135	I7-15-26	2.6	2.2
92-9145	I7-15-29	0.9	0.9
92-8455	I7-16-8	6.2	3.3
92-5215	I7-16-11	38.5	18.5
92-5225	I7-16-26	7.9	4.1
92-5235	I7-16-29	11.2	5.7
92-5125	I7-17-8	2.6	1.8
92-5135	I7-17-11	5.0	2.8
92-5145	I7-17-26	2.0	1.4
92-5155	I7-17-29	9.0	4.6
92-4503	I7-18-8	0.8	0.8
92-4513	I7-18-11	14.8	7.3
92-4525	I7-18-26	19.0	9.3
92-4535	I7-18-29	1.4	1.1
92-49 5	I7-19-8	1.6	1.2
92-4923	I7-19-11	0.6	0.7
92-4935	I7-19-26	2.5	1.6
92-4945	I7-19-29	2.2	1.4
92-3155	I7-20-8	2.7	2.3
92-3165	I7-20-11	1.8	1.3
92-3175	I7-20-26	2.5	1.8
92-3185	I7-20-29	2.2	2.0
92-5245	I7-21-8	7.2	3.8
92-5255	I7-21-11	7.8	4.0
92-5265	I7-21-26	14.6	7.2
92-5275	I7-21-29	27.3	13.2
92-5045	I7-22-8	8.0	4.2
92-5055	I7-22-11	4.0	2.3
92-5065	I7-22-26	2.1	1.4
92-5075	I7-22-29	13.8	6.8
92-5085	I7-23-8	14.5	7.2
92-5095	I7-23-11	19.0	9.4
92-5105	I7-23-26	2.1	1.4
92-5115	I7-23-29	17.0	8.4
92-8445	I7-24-8	4.4	2.5
92-5015	I7-24-11	7.8	4.1
92-5025	I7-24-26	2.9	1.8
92-5035	I7-24-29	1.5	1.1
92-2895	I7-25-8	2.5	2.2
92-2905	I7-25-11	1.8	1.2
92-2915	I7-25-26	1.3	1.0
92-2925	I7-25-29	1.7	1.2
	Average	5.4	3.2

ARCO Bluewater Mill
Soil Sample Results

Sample ID#	Description	Ra-226 Content (pCi/gm) Soil	Bulk Average
		Grid Block J3	
93-6325	J3-6-25	2.6	2.9
93-7415	J3-11-11	3.9	3.5
93-7425	J3-11-26	4.6	3.9
93-7435	J3-11-29	2.0	2.5
93-27965	J3-16-8	4.8	3.8
93-27975	J3-16-11	3.1	3.0
93-27985	J3-16-26	4.3	3.7
93-27995	J3-16-29	3.6	3.3
93-27265	J3-17-26	3.0	3.0
93-27605	J3-21-8	1.3	2.1
93-27615	J3-21-11	4.2	3.6
93-6895	J3-21-26	5.9	4.5
93-27625	J3-21-29	6.9	5.0
93-27755	J3-22-8	1.4	2.1
93-27745	J3-22-11	3.8	3.4
93-6845	J3-22-26	3.8	3.4
93-27735	J3-22-29	1.3	2.1
93-6305	J3-23-26	6.8	5.0
	Average	3.7	3.4

ARCO Bluewater Mill
Soil Sample Results

Sample ID #	Description	Ra – 226 Content (pCi/gm) Soil	Bulk Average
		Grid Block J6	
93-30225	J6-2-8	2.3	1.5
92-5825	J6-7-11	4.0	2.3
93-30215	J6-2-26	11.8	6.0
93-30235	J6-2-29	1.7	1.2
93-29735	J6-3-8	7.6	3.9
93-29745	J6-3-11	0.9	0.8
93-29755	J6-3-26	3.7	2.1
93-29765	J6-3-29	8.4	4.3
93-30015	J6-4-8	2.6	1.7
93-30025	J6-4-11	7.3	3.8
93-30035	J6-4-26	1.3	1.0
93-30045	J6-4-29	3.3	1.9
93-29695	J6-5-8	12.6	6.4
93-29705	J6-5-11	4.0	2.3
93-29715	J6-5-26	2.2	1.5
93-29725	J6-5-29	5.8	3.1
93-30085	J6-7-8	1.1	0.9
93-30095	J6-7-11	11.8	6.0
93-30105	J6-7-26	7.7	4.0
93-30115	J6-7-29	9.9	5.0
93-30165	J6-8-8	3.6	2.1
93-30175	J6-8-11	8.7	4.5
93-30185	J6-8-26	2.2	1.4
93-30195	J6-8-29	2.2	1.5
93-29895	J6-9-8	1.2	1.0
93-29905	J6-9-11	2.1	1.4
93-29915	J6-9-26	5.0	2.7
93-29925	J6-9-29	16.8	8.2
93-29955	J6-10-8	4.5	2.5
93-29965	J6-10-11	11.5	5.8
93-29975	J6-10-26	14.0	7.0
93-29985	J6-10-29	11.4	5.8
93-29975	J6-11-8	6.2	3.3
93-29985	J6-11-11	0.5	0.6
93-29995	J6-11-26	0.8	0.8
93-30005	J6-11-29	12.1	6.1
93-29495	J6-12-8	8.3	4.3
92-29505	J6-12-11	2.1	1.4
92-29515	J6-12-26	9.1	4.7
93-29525	J6-12-29	2.0	1.4
93-29935	J6-13-8	9.5	4.9
93-29945	J6-13-11	6.7	3.6
93-29955	J6-13-26	1.3	1.0
93-29965	J6-13-29	1.0	0.9
93-29615	J6-14-8	2.9	1.8
93-29625	J6-14-11	5.9	3.2
93-29535	J6-14-26	10.1	5.1
93-29645	J6-14-29	7.3	3.9
92-2055	J6-15-8	4.4	2.5
93-31925	J6-15-11	20.3	11.4
93-31935	J6-15-26	4.8	2.7
92-2085	J6-15-29	6.6	3.5
93-29955	J6-16-8	6.3	3.3
93-29965	J6-16-11	0.8	0.8
93-29675	J6-16-26	1.8	1.2
93-29985	J6-16-29	24.9	12.1
93-30125	J6-17-8	8.8	4.5
93-30135	J6-17-11	14.0	7.0
93-30145	J6-17-26	17.4	8.6
93-30155	J6-17-29	14.4	7.2
93-30675	J6-18-8	1.5	1.1
93-30685	J6-18-11	3.4	2.0
93-30695	J6-18-26	17.0	8.4
93-30705	J6-18-29	1.4	1.1
93-30725	J6-19-8	2.1	1.4
93-30735	J6-19-11	1.5	1.1
93-30745	J6-19-26	5.0	2.7
93-30755	J6-19-29	7.9	4.1
92-2285	J6-20-8	2.0	1.3
93-31835	J6-20-11	11.4	5.8
93-31885	J6-20-26	4.5	2.5
93-31875	J6-20-29	5.1	2.8
93-31565	J6-21-8	4.5	2.5
93-31585	J6-21-29	11.6	5.9
93-31605	J6-22-8	5.3	2.9
93-31615	J6-22-11	7.9	4.1
93-31625	J6-22-26	19.3	9.5
93-31635	J6-22-29	5.8	3.0
93-31885	J6-23-8	36.0	17.3
93-31895	J6-23-11	8.2	4.3
93-31905	J6-23-26	38.5	18.5
93-31915	J6-23-29	4.5	2.5
93-31825	J6-24-8	10.6	5.4
93-31835	J6-24-11	4.5	2.5
93-31845	J6-24-26	3.9	2.3
92-6225	J6-24-29	10.4	5.3
92-5975	J6-25-8	4.7	2.6
93-33775	J6-25-11	9.0	4.2
93-33785	J6-25-26	1.0	0.9
92-8465	J6-25-29	3.9	2.2
	Average	7.3	3.8

ARCO Bluewater Mill
Soil Sample Results

Sample ID #	Description	Ra - 226 Content (pCi/gm) Soil	Bulk Average
		Grid Block J7	
93-29605	J7-1-8	6.9	3.6
92-5375	J7-1-11	5.0	2.7
92-5385	J7-1-26	5.0	2.8
92-5395	J7-1-29	30.7	14.8
92-5165	J7-2-8	13.3	5.7
92-5175	J7-2-11	0.1	0.4
92-5185	J7-2-26	2.3	1.5
92-5195	J7-2-29	44.7	21.4
92-2735	J7-3-8	35.7	17.2
92-2745	J7-3-11	9.1	4.7
92-2755	J7-3-26	22.1	10.8
92-2765	J7-3-29	38.0	18.3
92-4955	J7-4-8	5.1	2.9
92-4965	J7-4-11	6.2	3.3
92-4975	J7-4-26	5.0	2.8
93-4985	J7-4-29	2.5	1.6
92-3105	J7-5-8	2.2	1.4
92-3115	J7-5-11	2.5	1.6
92-3125	J7-5-26	2.2	1.4
92-3135	J7-5-29	2.1	1.4
92-5485	J7-6-8	13.8	6.9
92-5495	J7-6-11	3.8	2.1
92-5505	J7-6-26	10.3	5.2
92-5515	J7-6-29	15.0	7.4
92-2575	J7-7-8	7.9	4.1
92-2585	J7-7-11	3.4	2.0
92-2595	J7-7-26	10.5	5.3
92-2605	J7-7-29	1.8	1.2
92-2615	J7-8-8	37.3	17.9
92-2625	J7-8-11	6.2	3.3
92-2635	J7-8-26	7.5	3.9
92-2645	J7-8-29	30.5	14.7
92-2655	J7-9-8	11.3	5.7
92-2665	J7-9-11	7.8	4.1
92-2675	J7-9-26	6.6	3.5
92-2685	J7-9-29	10.3	5.2
92-2935	J7-10-8	2.3	1.5
92-2945	J7-10-11	3.2	1.9
92-2955	J7-10-26	4.8	2.6
92-2965	J7-10-29	1.6	1.2
92-5405	J7-11-8	15.1	7.5
92-5415	J7-11-11	11.1	5.6
92-5425	J7-11-26	2.2	1.4
92-5435	J7-11-29	1.8	1.3
93-3495	J7-12-8	3.7	2.2
92-2505	J7-12-11	7.0	3.7
93-2515	J7-12-26	9.0	4.6
92-2525	J7-12-29	0.9	0.8
92-2255	J7-13-8	10.5	5.3
92-2265	J7-13-11	30.9	14.9
92-2275	J7-13-26	9.6	4.9
92-2285	J7-13-29	11.8	5.9
92-2535	J7-14-8	13.2	6.6
92-2545	J7-14-11	7.6	4.0
92-2555	J7-14-26	4.3	2.4
92-2565	J7-14-29	6.6	3.5
92-2975	J7-15-8	3.8	2.2
92-2985	J7-15-11	1.1	0.9
92-2995	J7-15-26	2.6	1.6
92-3005	J7-15-29	0.8	0.7
92-2085	J7-16-8	8.0	4.2
92-2105	J7-16-11	5.2	2.9
92-2115	J7-16-26	5.3	2.9
92-2125	J7-16-29	12.5	6.3
92-2335	J7-17-8	6.0	3.2
92-2345	J7-17-11	3.5	2.0
92-2355	J7-17-26	2.8	1.7
92-2365	J7-17-29	8.9	4.6
92-2135	J7-18-8	5.3	2.9
92-2145	J7-18-11	24.2	11.8
92-2155	J7-18-26	11.4	5.8
92-2165	J7-18-29	8.3	4.3
92-2215	J7-19-8	9.2	4.7
92-2225	J7-19-11	8.1	4.2
92-2235	J7-19-26	4.4	2.5
92-2245	J7-19-29	14.3	7.1
92-2695	J7-20-8	3.9	2.2
92-2705	J7-20-11	13.1	6.6
92-2715	J7-20-26	6.4	3.4
93-34525	J7-20-29	0.5	0.7
92-5935	J7-21-8	7.7	4.0
92-5945	J7-21-11	10.3	5.2
92-5955	J7-21-26	3.1	1.9
92-5965	J7-21-29	2.8	1.7
92-6235	J7-22-8	4.7	2.6
92-6245	J7-22-11	0.9	0.8
92-6255	J7-22-26	4.7	2.6
93-33715	J7-22-29	4.4	2.5
93-33765	J7-23-26	4.5	2.5
92-2415	J7-24-8	22.7	11.1
92-2425	J7-24-11	14.3	7.1
92-2435	J7-24-26	9.2	4.7
92-2445	J7-24-29	16.8	8.3
93-34545	J7-25-8	0.8	0.6
92-2455	J7-25-11	16.4	8.1
92-2475	J7-25-26	9.7	5.0
93-34555	J7-25-29	3.9	2.2
	Average	9.1	4.7

ARCO Bluewater Mill
Soil Sample Results

Sample ID#	Description	Ra-226 Content (pCi/gm) Soil	Bulk Average
		Grid Block J8	
92-3025	J8-1-8	6.4	6.4
92-3035	J8-1-11	2.4	2.1
92-3045	J8-1-26	2.5	1.8
92-3055	J8-1-29	3.3	2.7
92-3205	J8-2-8	1.2	1.2
92-3215	J8-2-11	2.0	1.8
92-3225	J8-2-26	3.5	2.9
92-3235	J8-2-29	1.8	1.7
92-9155	J8-3-8	2.0	1.8
92-9165	J8-3-11	1.6	1.6
92-9175	J8-3-26	2.1	1.9
92-9185	J8-3-29	1.5	1.4
92-9335	J8-4-8	1.2	1.2
92-9345	J8-4-11	2.7	2.0
92-9355	J8-4-26	1.0	1.1
92-9365	J8-4-29	6.8	5.2
92-10015	J8-5-8	3.4	2.8
92-10025	J8-5-11	1.0	1.1
92-10035	J8-5-26	2.9	2.5
92-10045	J8-5-29	2.4	2.1
92-2775	J8-6-8	3.4	2.8
92-2785	J8-6-11	3.6	2.1
92-2795	J8-6-26	2.0	1.3
92-2805	J8-6-29	2.1	1.4
92-3255	J8-7-8	2.2	1.9
92-3265	J8-7-11	3.4	2.8
92-3275	J8-7-26	3.1	2.6
92-3285	J8-7-29	2.4	2.1
92-3545	J8-8-8	2.7	2.3
92-3555	J8-8-11	0.9	1.0
92-3565	J8-8-26	4.5	3.6
92-3575	J8-8-29	2.6	2.2
92-10175	J8-9-8	3.0	2.5
92-10185	J8-9-11	-1.7	-0.8
92-10195	J8-9-26	4.6	3.7
92-10205	J8-9-29	-0.5	0.0
92-10035	J8-10-8	0.1	0.5
92-10045	J8-10-11	2.7	2.3
92-10055	J8-10-26	5.8	4.4
92-10066	J8-10-29	3.4	2.8
92-2815	J8-11-8	4.3	2.4
92-2825	J8-11-11	4.8	2.7
92-2835	J8-11-26	3.7	2.1
92-2845	J8-11-29	4.1	2.3
92-3735	J8-12-8	1.2	1.2
92-3745	J8-12-11	5.3	4.2
92-3755	J8-12-26	0.8	0.9
92-3765	J8-12-29	-0.3	0.2
92-3395	J8-13-8	2.1	1.9
92-3405	J8-13-11	1.3	1.3
92-3415	J8-13-26	1.9	1.7
92-3425	J8-13-29	2.0	1.8
92-3345	J8-14-8	3.2	2.7
92-3355	J8-14-11	1.9	1.8
92-3365	J8-14-26	4.1	3.3
92-3375	J8-14-29	2.1	1.9
93-6025	J8-15-8	3.6	3.0
93-5035	J8-15-11	1.9	1.8
93-6045	J8-15-26	1.2	1.2
93-6056	J8-15-29	4.4	3.5
92-2855	J8-16-8	4.9	2.7
92-2865	J8-16-11	1.8	1.3
93-34585	J8-16-26	1.8	1.3
92-2885	J8-16-29	1.8	1.2
92-3905	J8-17-8	3.2	1.9
92-3915	J8-17-11	3.3	2.0
92-3925	J8-17-26	2.1	1.4
92-3935	J8-17-29	4.2	2.4
92-4865	J8-18-8	2.1	1.9
92-4875	J8-18-11	1.5	1.5
92-4885	J8-18-26	4.0	2.4
92-4895	J8-18-29	0.9	1.1
92-3285	J8-19-8	2.4	2.1
92-3305	J8-19-11	3.0	2.5
92-3315	J8-19-26	2.8	2.4
92-3325	J8-19-29	1.7	1.8
92-3595	J8-20-8	2.3	2.0
92-8965	J8-20-11	2.4	2.1
92-3615	J8-20-26	2.8	0.4
92-3625	J8-20-29	2.5	2.2
92-6095	J8-21-8	3.7	2.2
92-6105	J8-21-11	18.4	9.1
93-34605	J8-21-26	1.8	1.2
92-6125	J8-21-29	-0.2	0.3
92-3695	J8-22-8	2.3	1.5
92-3705	J8-22-11	8.8	4.5
92-3715	J8-22-26	9.6	4.9
92-3725	J8-22-29	3.0	1.8
92-4825	J8-23-8	4.5	2.5
92-4835	J8-23-11	4.6	2.5
92-4845	J8-23-26	4.0	2.3
92-4855	J8-23-29	5.6	3.0
92-3445	J8-24-8	6.5	5.0
92-3455	J8-24-11	4.1	2.3
92-3465	J8-24-26	3.1	1.9
92-3475	J8-24-29	5.6	3.0
92-3485	J8-25-8	5.3	4.2
92-3505	J8-25-11	1.2	1.3
92-3515	J8-25-26	-0.0	0.4
92-3525	J8-25-29	3.1	2.6
	Average	3.0	2.2

ARCO Bluewater Mill
Soil Sample Results

Sample ID #	Description	Ra-226 Content (pCi/gm) Soil	Bulk Average
		Grid Block J9	
92-10365	J9-1-8	5.6	4.4
92-10375	J9-1-11	2.9	2.5
92-10385	J9-1-26	3.1	2.6
92-10395	J9-1-29	2.7	2.3
92-10815	J9-2-8	0.7	0.9
92-10825	J9-2-11	1.3	1.3
92-10835	J9-2-26	-0.1	0.3
92-10845	J9-2-29	2.8	2.4
93-11055	J9-5-29	2.2	1.9
92-9896	J9-6-8	1.0	1.1
92-9906	J9-6-11	2.4	2.1
92-9915	J9-6-26	2.8	2.4
92-9925	J9-6-29	2.2	2.0
93-10475	J9-7-8	7.1	5.5
93-10485	J9-7-11	1.1	1.2
93-10495	J9-7-26	0.7	0.9
93-10505	J9-7-29	1.4	1.4
93-10375	J9-8-8	1.9	1.8
93-10385	J9-8-11	5.3	4.1
93-10395	J9-8-26	2.0	1.8
93-10405	J9-8-29	4.3	3.5
93-11135	J9-9-26	2.1	1.9
93-11145	J9-9-29	1.3	1.3
93-11075	J9-10-8	2.4	2.1
93-11085	J9-10-29	3.8	3.1
92-10135	J9-11-8	3.9	3.1
92-10145	J9-11-11	2.1	1.9
92-10155	J9-11-26	1.3	1.3
92-10165	J9-11-29	2.5	2.1
93-10715	J9-12-8	1.5	1.5
93-10725	J9-12-11	6.3	4.9
93-10735	J9-12-26	1.7	1.6
93-10745	J9-12-29	2.0	1.8
93-36735	J9-13-8	1.0	1.1
93-36745	J9-13-11	1.0	1.1
93-36755	J9-13-26	1.4	1.4
93-36765	J9-13-29	2.4	2.1
93-10525	J9-14-8	3.6	2.9
93-10535	J9-14-11	2.4	2.1
93-10545	J9-14-26	4.9	3.8
93-10555	J9-14-29	4.1	3.3
93-8065	J9-16-8	4.7	3.6
93-8075	J9-16-11	1.2	1.3
93-8085	J9-16-26	3.6	2.9
93-8095	J9-16-29	3.3	2.7
92-9945	J9-17-8	0.9	1.1
92-9955	J9-17-11	2.3	2.1
92-8965	J9-17-26	-0.2	0.2
92-9975	J9-17-29	2.1	1.9
93-36835	J9-18-8	1.3	1.3
93-36845	J9-18-11	1.3	1.3
93-9955	J9-19-8	2.3	2.0
93-9965	J9-19-11	3.2	2.7
93-9975	J9-19-26	2.1	1.9
93-9985	J9-19-29	7.1	5.5
92-3995	J9-21-8	3.2	2.7
92-4005	J9-21-11	1.1	1.2
92-4015	J9-21-26	0.4	0.7
92-4025	J9-21-29	2.7	2.3
92-9415	J9-22-8	2.7	2.3
92-9425	J9-22-11	5.2	4.1
92-9435	J9-22-26	2.5	2.2
92-9445	J9-22-29	3.8	3.1
92-9985	J9-23-8	3.1	2.6
92-10005	J9-23-11	3.2	2.7
92-10015	J9-23-26	-1.7	-0.8
92-10025	J9-23-29	0.8	0.9
93-9725	J9-24-8	2.8	2.5
93-9735	J9-24-11	2.7	2.3
93-9745	J9-24-26	2.2	2.0
93-9755	J9-24-29	2.2	2.0
	Average	2.5	2.2

ARCO Bluewater Mill
Soil Sample Results

Sample ID #	Description	Ra-226 Content (pCi/gm) Soil	Bulk Average
Grid Block L4			
93-35615	L4-5-8	5.3	4.8
93-35625	L4-5-11	27.7	16.1
93-35635	L4-5-26	61.9	34.2
93-35585	L4-10-26	27.9	16.2
93-35595	L4-10-29	1.6	2.3
93-34855	L4-12-8	37.2	21.1
93-34865	L4-12-29	26.6	15.5
93-34895	L4-13-8	33.0	18.9
93-34905	L4-13-11	42.6	24.5
93-34915	L4-13-26	41.6	23.5
93-34925	L4-13-29	42.4	24.4
93-34695	L4-14-8	27.6	16.0
93-24705	L4-14-11	33.2	19.0
93-34715	L4-14-26	70.3	38.6
93-34725	L4-14-29	28.5	16.5
93-34615	L4-15-8	6.4	4.8
93-34625	L4-15-11	20.8	12.3
93-34635	L4-15-26	16.8	10.3
93-34645	L4-15-29	18.5	11.2
93-34825	L4-17-8	11.0	7.2
93-34835	L4-17-29	32.7	19.7
93-34795	L4-18-8	35.2	20.0
93-34795	L4-18-11	40.4	22.8
93-34805	L4-18-26	43.1	24.2
93-34815	L4-18-29	24.9	14.6
93-34655	L4-19-8	6.8	4.9
93-34665	L4-19-11	20.7	12.4
93-34675	L4-19-26	165.6	89.1
93-34685	L4-19-29	33.5	19.1
93-34735	L4-20-8	4.3	3.7
93-34745	L4-20-11	10.3	6.9
93-34755	L4-20-26	11.6	7.5
93-34765	L4-20-29	10.5	7.0
93-34945	L4-22-8	69.1	38.0
93-34875	L4-23-8	34.9	19.9
93-34885	L4-23-11	44.3	24.9
	Average	32.5	18.8
Grid Block L5			
93-35645	L5-1-8	3.0	3.0
93-35655	L5-1-11	1.5	2.3
93-36615	L5-6-8	2.0	2.5
93-36625	L5-6-11	4.3	3.7
93-36635	L5-6-26	7.8	5.5
93-36645	L5-6-29	1.2	2.1
93-36575	L5-11-8	8.6	6.0
93-36585	L5-11-26	0.9	1.9
93-36595	L5-11-29	20.5	12.3
93-36875	L5-12-8	41.5	23.4
93-36885	L5-12-11	22.1	13.1
93-36895	L5-12-26	14.3	9.0
93-36905	L5-12-29	178.5	86.0
93-36985	L5-16-8	23.6	13.9
93-36995	L5-16-11	1.7	2.3
93-36915	L5-17-8	3.7	3.3
93-36925	L5-17-11	6.2	4.7
93-36935	L5-17-29	19.6	11.8
93-36945	L5-22-8	14.9	9.3
93-36955	L5-22-11	23.8	13.9
93-36965	L5-22-26	33.3	19.1
93-36975	L5-22-29	22.5	13.3
	Average	20.7	12.4
Grid Block N4			
94-00255	N4-14-8	20.8	12.4
94-00265	N4-14-11	12.8	8.2
94-00275	N4-14-26	15.6	9.7
94-00285	N4-14-29	13.8	8.7
94-00335	N4-15-8	7.9	5.6
94-00345	N4-15-11	15.7	9.7
94-00350	N4-15-26	5.6	4.4
94-00360	N4-15-29	30.8	17.7
93-8145	N4-17-8	6.1	4.6
93-8155	N4-17-11	11.4	7.4
93-8165	N4-17-29	1.9	2.4
93-7865	N4-18-8	3.0	3.5
93-7875	N4-18-11	9.1	6.2
93-7885	N4-18-26	1.1	2.0
93-7895	N4-18-29	11.0	7.2
94-00295	N4-19-8	5.7	4.4
93-8185	N4-19-11	7.5	5.4
94-00305	N4-19-29	7.2	5.2
94-00415	N4-20-8	8.1	5.7
94-00425	N4-20-11	6.5	4.8
94-00435	N4-20-26	9.2	6.3
94-00445	N4-20-29	5.5	4.3
93-8595	N4-23-8	2.1	2.5
93-8695	N4-24-8	1.8	2.4
93-8705	N4-24-11	2.9	2.9
93-8715	N4-24-29	1.2	2.0
93-8835	N4-25-11	4.1	3.6
93-8845	N4-25-26	2.5	2.7
93-8855	N4-25-29	1.9	2.4
	Average	8.1	5.7

ARCO Bluewater Mill
Soil Sample Results

Sample ID #	Description	Ra-226 Content (pCi/gm) Soil	Bulk Average
		Grid Block N5	
93-9215	N5-4-8	23.9	14.1
93-9225	N5-4-11	31.0	17.9
93-9235	N5-4-26	19.3	11.6
93-9245	N5-4-29	8.1	4.6
93-9025	N5-8-8	9.2	5.3
93-9045	N5-8-26	8.4	5.0
93-93135	N5-8-29	2.6	2.0
93-8985	N5-9-8	7.2	5.2
93-8995	N5-9-11	7.8	5.5
93-9005	N5-9-26	4.9	4.0
93-9015	N5-9-29	5.0	4.1
93-9165	N5-10-8	13.9	8.8
93-9175	N5-10-11	45.0	25.3
93-9185	N5-10-26	8.8	5.1
93-9195	N5-10-29	2.8	2.9
94-00455	N5-11-11	53.1	29.5
94-00465	N5-11-26	9.8	5.0
93-9265	N5-11-26	22.4	13.3
93-12575	N5-12-8	9.5	5.9
93-35045	N5-13-8	3.0	3.0
93-35055	N5-13-11	32.4	18.6
93-8415	N5-13-26	11.6	7.5
93-35065	N5-13-29	6.5	4.8
93-35075	N5-14-8	2.7	2.8
93-35085	N5-14-11	5.3	4.2
93-35095	N5-14-26	8.8	6.1
93-35105	N5-14-29	8.5	5.9
93-35115	N5-15-11	12.1	7.8
93-35125	N5-15-26	3.5	3.3
93-8325	N5-15-29	4.8	3.9
94-00375	N5-16-8	47.5	26.6
94-00385	N5-16-11	20.1	12.1
94-00395	N5-16-26	9.8	6.6
94-00405	N5-16-29	46.5	26.0
94-00855	N5-17-26	18.2	11.0
94-00085	N5-17-29	9.1	6.2
94-00475	N5-18-8	82.1	44.9
93-34975	N5-19-8	3.1	3.0
94-00485	N5-19-11	29.9	17.2
93-34985	N5-19-26	69.1	38.0
93-35005	N5-19-29	2.3	2.6
93-35015	N5-20-11	4.1	3.6
93-35025	N5-20-26	2.3	2.6
93-35035	N5-20-29	6.5	4.8
93-8115	N5-21-26	1.1	2.0
93-8125	N5-21-29	1.6	2.2
94-00115	N5-22-8	16.4	10.1
94-00495	N5-22-11	6.5	4.8
93-8225	N5-22-26	2.1	2.5
93-8235	N5-22-29	5.9	4.5
93-12615	N5-23-11	33.4	19.1
93-12625	N5-23-26	20.4	12.2
93-34935	N5-24-8	9.3	5.9
93-34945	N5-24-11	1.2	2.0
93-34955	N5-24-29	3.1	3.0
93-8485	N5-25-8	3.3	3.1
93-8495	N5-25-11	9.4	6.4
93-8505	N5-25-26	5.3	4.2
93-8515	N5-25-29	1.9	2.4
	Average	14.5	9.1

ARCO Bluewater Mill
Soil Sample Results

Sample ID #	Description	Ra-226 Content (pCi/gm) Soil	Bulk Average
Grid Block N6			
93-8765	N6-11-11	8.6	5.9
93-8775	N6-11-26	19.0	11.5
93-12485	N6-16-11	9.7	6.5
93-12555	N6-16-26	14.5	9.1
93-12515	N6-16-29	1.5	2.2
93-8535	N6-21-8	3.7	3.3
93-8545	N6-21-11	6.8	5.0
93-8555	N6-21-26	2.6	2.8
93-8565	N6-21-29	8.7	6.0
	Average	8.3	5.8
Grid Block G6			
93-27015	G-06-6-8	3.5	2.9
93-27025	G-06-6-11	1.4	1.4
93-27035	G-06-6-26	3.9	3.2
93-27045	G-06-6-29	0.7	0.9
93-26695	G-06-7-8	4.9	3.9
93-26705	G-06-7-11	1.1	1.2
93-26665	G-06-7-26	0.9	1.0
93-26675	G-06-7-29	0.5	0.8
93-26715	G-06-11-8	3.6	2.9
93-26725	G-06-11-11	10.6	8.0
93-26735	G-06-11-26	31.3	22.6
93-26745	G-06-11-29	86.2	61.6
93-25185	G-06-12-8	1.0	1.1
93-25175	G-06-12-11	0.7	0.9
93-25185	G-06-12-26	2.3	2.0
93-25195	G-06-12-29	1.2	1.2
93-25215	G-06-13-8	2.3	2.0
93-25225	G-06-13-11	1.0	1.1
93-25235	G-06-13-26	1.2	1.2
93-25245	G-06-13-29	0.9	1.0
93-25015	G-06-17-8	0.9	1.0
93-25025	G-06-17-11	2.1	1.9
93-25035	G-06-17-26	1.1	1.2
93-25045	G-06-17-29	1.5	1.4
93-25065	G-06-18-8	0.9	1.0
93-25075	G-06-18-11	1.2	1.2
93-25085	G-06-18-26	7.8	6.0
93-25095	G-06-18-29	0.7	0.9
93-25115	G-06-19-8	2.8	2.4
93-25125	G-06-19-11	0.7	0.9
93-25135	G-06-19-26	1.0	1.1
93-25145	G-06-19-29	1.8	1.6
94-00125	G-06-22-8	2.7	2.3
94-00135	G-06-22-11	2.4	2.1
94-00145	G-06-22-26	0.8	1.0
94-00155	G-06-22-29	2.3	2.0
93-24875	G-06-23-8	1.9	1.8
93-24885	G-06-23-11	6.3	4.9
93-24895	G-06-23-26	1.3	1.3
93-24905	G-06-23-29	3.5	2.9
93-24925	G-06-24-8	1.9	1.7
93-24935	G-06-24-11	2.3	2.0
93-24945	G-06-24-26	14.7	10.8
93-24955	G-06-24-29	3.7	3.0
93-24965	G-06-25-8	3.1	2.6
93-24975	G-06-25-11	0.7	0.8
93-24985	G-06-25-26	2.2	1.9
	Average	4.9	3.9

ARCO Bluewater Mill
Soil Sample Results

Sample ID #	Description	Ra -226 Content (pCi/gm) Soil	Bulk Average
Grid Block H7			
93-25675	H7-1-8	1.5	1.3
93-25685	H7-1-11	3.8	3.1
93-25695	H7-1-26	2.9	2.5
93-25705	H7-1-29	3.3	2.8
93-24475	H7-2-8	1.0	1.1
93-24485	H7-2-11	1.0	1.1
93-24495	H7-2-26	1.4	1.4
93-24505	H7-2-29	1.3	1.3
93-23805	H7-6-8	3.0	2.6
93-23775	H7-6-11	13.0	9.7
93-23785	H7-6-26	5.4	4.3
93-23795	H7-6-29	1.7	1.6
93-24725	H7-7-8	1.1	1.2
93-24730	H7-7-11	2.1	1.8
93-24745	H7-7-26	0.5	0.7
93-24755	H7-7-29	2.3	2.1
93-24775	H7-8-8	1.5	1.4
93-24785	H7-8-11	2.3	2.0
93-24795	H7-8-26	4.7	3.7
93-24805	H7-8-29	1.4	1.4
93-24525	H7-11-8	3.2	2.7
93-24535	H7-11-11	3.6	3.0
93-24545	H7-11-26	1.8	1.7
93-24555	H7-11-29	2.1	1.9
93-24625	H7-12-8	2.3	2.0
93-24635	H7-12-11	2.6	2.3
93-25265	H7-12-26	1.7	1.6
93-24655	H7-12-29	1.9	1.7
93-24675	H7-13-8	2.1	1.9
93-24685	H7-13-11	8.4	6.4
93-24695	H7-13-26	6.0	4.7
93-24705	H7-13-29	2.3	2.1
93-24425	H7-14-8	1.5	1.5
93-24435	H7-14-11	1.8	1.7
93-24445	H7-14-26	2.3	2.0
93-24455	H7-14-29	3.1	2.6
92-7555	H7-16-26	9.2	7.0
93-25865	H7-17-8	0.8	1.0
93-25875	H7-17-11	2.4	2.1
93-25885	H7-17-26	1.9	1.7
93-25895	H7-17-29	2.0	1.8
93-24375	H7-18-8	1.9	1.8
93-24385	H7-18-11	2.0	1.8
93-24395	H7-18-26	1.6	1.5
93-24405	H7-18-29	1.7	1.6
93-27765	H7-19-8	2.8	2.4
93-27775	H7-19-11	4.4	3.6
93-27785	H7-19-26	1.7	1.3
93-27795	H7-19-29	2.3	2.0
93-24325	H7-20-8	1.8	1.7
93-24335	H7-20-11	3.4	2.8
93-24345	H7-20-26	2.7	2.3
93-24355	H7-20-29	1.8	1.7
92-7485	H7-21-8	5.2	4.1
92-7495	H7-21-11	6.7	5.1
92-7505	H7-21-26	4.8	3.6
92-7515	H7-21-29	12.7	9.4
93-5885	H7-22-8	4.1	3.3
93-5895	H7-22-11	2.4	2.1
93-5905	H7-22-26	5.9	4.6
93-25775	H7-22-11	1.7	1.6
93-25785	H7-22-26	2.7	2.3
93-25795	H7-22-29	2.6	2.3
93-26865	H7-24-8	3.0	2.6
93-26875	H7-24-11	1.9	1.7
93-26885	H7-24-26	1.3	1.3
93-26890	H7-24-29	2.0	1.8
93-26815	H7-25-8	2.5	2.1
93-26825	H7-25-11	2.5	2.2
93-26835	H7-25-26	1.5	1.5
93-26845	H7-25-29	2.7	2.3
	Average	3.0	2.5

ARCO Bluewater Mill
Soil Sample Results

Sample ID#	Description	Ra-226 Content (pCi/gm) Soil	Bulk Average
Grid Block H8			
93-26915	H8-21-8	1.4	1.4
93-26925	H8-21-11	2.0	1.8
93-26935	H8-21-26	1.8	1.7
93-26945	H8-21-29	1.5	1.5
	Average	1.7	1.6
Grid Block I8			
93-25365	I8-1-8	1.6	1.5
93-25375	I8-1-11	1.7	1.6
93-25385	I8-1-26	1.5	1.5
93-25395	I8-1-29	2.5	2.2
93-25475	I8-2-8	1.2	1.3
93-25485	I8-2-11	2.1	1.9
93-25495	I8-2-26	1.5	1.5
93-25505	I8-2-29	2.3	2.1
93-25315	I8-5-8	1.1	1.2
93-25325	I8-5-11	1.0	1.1
93-25335	I8-5-26	0.9	1.0
93-25345	I8-5-29	0.6	0.9
93-24575	I8-6-8	2.2	2.0
93-24585	I8-6-11	0.8	0.9
93-24595	I8-6-26	6.2	4.9
93-24605	I8-6-29	1.8	1.5
94-00175	I8-7-8	1.2	1.3
94-00185	I8-7-11	1.4	1.4
94-00195	I8-7-26	3.7	3.0
94-00205	I8-7-29	1.9	1.7
93-25415	I8-8-8	1.3	1.3
93-25425	I8-8-11	1.5	1.5
93-25435	I8-8-26	1.7	1.6
93-25445	I8-8-29	1.7	1.6
93-25525	I8-9-8	0.9	1.0
93-25535	I8-9-11	0.4	0.7
93-25545	I8-9-26	1.0	1.1
93-25555	I8-9-29	1.5	2.2
93-25615	I8-11-8	1.8	1.7
93-25625	I8-11-11	6.9	5.5
93-25635	I8-11-26	0.9	1.0
93-25645	I8-11-29	1.6	1.6
93-25725	I8-12-8	2.4	2.1
93-25735	I8-12-11	1.0	1.1
93-25745	I8-12-26	1.7	1.6
93-25755	I8-12-29	1.2	1.3
93-25625	I8-13-8	0.7	0.9
93-25635	I8-13-11	1.6	1.6
93-25645	I8-13-26	1.1	1.2
93-25655	I8-13-29	2.3	2.0
93-25575	I8-14-8	3.4	2.8
93-25585	I8-14-11	1.7	1.6
93-25595	I8-14-26	2.3	2.0
93-25605	I8-14-29	2.2	1.9
92-10265	I8-15-8	0.4	0.7
92-10275	I8-15-11	16.7	12.3
92-10285	I8-15-26	6.9	5.3
92-10295	I8-15-29	4.8	3.8
93-5925	I8-16-8	2.3	2.1
93-5935	I8-16-11	1.9	1.7
93-5945	I8-16-26	2.2	2.0
93-5955	I8-16-29	1.6	1.5
92-9295	I8-17-8	2.9	2.5
92-9305	I8-17-11	8.4	6.4
92-9315	I8-17-26	3.3	2.7
92-9325	I8-17-29	3.4	2.8
92-11218	I8-18-8	7.9	6.0
92-9515	I8-19-11	3.6	3.0
92-9525	I8-18-26	1.9	1.7
92-9535	I8-18-29	1.6	1.5
92-9555	I8-19-8	2.1	1.9
92-9565	I8-19-11	3.9	3.1
92-9575	I8-19-26	9.1	6.8
92-9585	I8-19-29	3.0	2.5
92-9795	I8-20-8	4.2	3.3
92-9805	I8-20-11	1.7	1.6
92-9815	I8-20-26	6.4	4.9
92-9825	I8-20-29	6.4	4.9
92-3065	I8-21-8	2.3	2.1
92-3075	I8-21-11	3.4	2.8
92-3085	I8-21-26	1.9	1.8
92-3095	I8-21-29	4.2	3.4
93-5975	I8-22-8	2.1	1.9
93-5985	I8-22-11	2.7	2.3
93-5995	I8-22-26	1.5	1.5
93-6005	I8-22-29	1.4	1.4
92-9685	I8-23-8	4.5	3.6
92-9705	I8-23-11	1.5	1.5
92-9715	I8-23-26	4.9	3.9
92-9725	I8-23-29	2.4	2.1
92-9585	I8-25-8	2.9	2.4
92-9605	I8-25-11	7.2	5.5
92-9615	I8-25-26	3.2	2.7
92-9625	I8-25-29	7.2	5.6
	Average	2.9	2.4

Appendix B

Determination of Factors for Accounting for Rocks in the Top 15-cm Layer

Table of Contents

List of Figures

List of Tables

Determination of Factors for Accounting for the Rocks in the Top 15-cm Layer

B.1 Introduction

In order to conduct a risk assessment for residual contamination at the Bluewater Mill Site, a correction for the amount of rock in the surface layer (top 15 cm) was required. The rock at the site is known to consist of near natural background levels of Ra-226 and does not emanate Rn-222 readily. In addition, the rock does not add to the source term for airborne radioactivity. In fact, reductions in the particulate emission rates are appropriate for rough surfaces such as rocky areas. In order to compensate for the presence of rock, the U. S. Department of Energy has developed a procedure to calculate a "bulk average Ra-226 concentration" based on the percentage of rock in the surface layer and the measured Ra-226 concentrations of the rock and soil. This appendix describes the studies done to apply this method to the surface layer at the Bluewater Mill Site and the adjustment factors that resulted from the studies. Since all data suggest that the contamination exists only in the surface layer for these areas, the study addresses only the top 6-inch layer.

Standard industrial equipment was used to clean the off-pile areas to comply with the cleanup standard of 5 pCi/g above background (6.9 pCi/g) for the surface soils. After several attempts at cleaning the areas to meet the cleanup criterion, the final soil verification data indicated that the residual soil for a portion of the area does not meet the 6.9 pCi/g cleanup criterion. These areas normally consist of a thin rock/soil layer over bedrock. A region of the site that includes these areas has been defined as the exemption area as shown in Figure B-1.

The exemption area consists of four distinctively different areas that have been treated separately. The first and largest area is the Malpais Exclusion Area that was discussed in the approved ARCO Bluewater Mill Reclamation Plan. No additional data have been obtained for this area. However, the area has been addressed in this appendix using

previously collected data. The risk assessment has included the Malpais Exclusion Area in order to assess the cumulative effects of the area along with the other areas within the exemption area.

The areas are divided by the type of near-surface geological formations. These are the Chinle formation, a soft red sandstone, the limestone formation, and the lava rock formation. The approximate boundaries of the areas are shown in Figure B-1.

B.2 Procedure for Assessing Percentage of Rock in Surface Layer

A map was used to select approximately 20 evenly-spaced sampling points in each of the three geological areas. Technicians were instructed to go to each point and collect all of the soil and removable rock from a 12-inch diameter area to a 6-inch (15 cm) depth. If the rock and soil mixture was less than six inches deep prior to hitting bed rock, the depth of the rock/soil mixture was recorded. Otherwise, the depth to bedrock was recorded as six inches. In order to assure an unbiased sampling location, the technician went to the grid stake indicating the location, and threw an object into the air. The sampling point was defined as the point of impact upon falling. It was decided to not use the grid stake locations since they may have been shifted a few inches at some locations to avoid rocks, providing a better location to drive the grid stake. This would have biased the results of the measurements.

The soil and rock mixture for each location was weighed. It was then placed in a 1.5-inch screen mesh. The weight of the rock that did not pass through the screen was then determined. This rock size was typical of the pieces of rock that were discarded during soil sampling for verification. The rock from approximately 10 locations from each geological formation were crushed and analyzed for Ra-226. The moisture content of the material was ignored since the material was very dry.

B.3 Ra-226 Adjustment Factors for the Lava, Chinle, and Limestone Formations

The rock size data for the three geological formations are provided in Table B-1. The measured percentage of rock in the material gathered at each location, the approximate coordinates of the sampling point, and the depth to bedrock is given. The mean percentage of rock (P_r) in the soil/rock mixture and the mean depth to bedrock (D_r) was used to calculate the percentage of soil in the top 15 cm layer for each of the formations. In order to follow a procedure similar to that which the Department of Energy uses at the UMTRA sites, the lower 95th percent confidence level of the mean percentage of rock in the top 15 cm layer and the upper 95th percent confidence level of the Ra-226 in the rock was used in developing a factor to adjust the measured Ra-226 concentration. In order to make the calculations simple as well as conservative, we have assumed the density of rock and soil are the same. The percentage of rock in the top 15 cm layer, P_R, is equal to the percentage in the rock/soil matrix plus the percentage in the bedrock layer.

$$P_R = P_{R'} + P_{R''}$$

$$P_R = (P_r)(D_r/6) + (6 - D_r)/6$$

where the upper 95% confidence of the mean Ra-226 concentration was used for the rock. D_r is given in inches.

The algorithm for determining the bulk average Ra-226 concentration in the top 15-cm layer for each of the formations is simply a mass weighting of the soil and rock Ra-226 concentrations. Data indicate that the Ra-226 concentration in the soil/rock matrix is higher than that for the bedrock material. This may arise from surface contamination or possibly ore in the sample. Therefore the mean Ra-226 concentrations at the upper 95 percent confidence level were used for both bedrock and rock in the soil matrix to adjust the Ra-226 concentration to that in the top 15 cm layer.

The measured Ra-226 concentrations in the rock from the rock/soil matrix from the geological areas is provided in Table B-2. The Ra-226 content of the bedrock is given in Table B-3. The errors shown are the standard errors. The upper 95 percent confidence level was calculated and used with the following algorithm:

$$\text{Bulk Average Ra-226} = (P_S)(C_S) + (P_{R'})(C_{R'}) + (P_{R''})(C_{R''})$$

where P_S and P_R are the soil and rock percentages in the top 15 cm layer and C_S, $C_{R'}$, and $C_{R''}$ are the Ra-226 concentrations in the soil, loose rock, and bedrock, respectively. The upper 95% confidence level of the mean Ra-226 concentration in the rock was used, consistent with the DOE protocol.

Using the data in Tables B-1, B-2, and B-2, the bulk average Ra-226 concentration for the three geological formations are:

For Chinle Sandstone

$$\text{Bulk Average Ra-226 (pCi/g)} = (0.71)(C_S) + (0.044)(2.3) + (0.25)(1.2)$$

$$= (0.71)(C_S) + 0.4$$

For Lava Area

$$\text{Bulk Average Ra-226 (pCi/g)} = (0.53)(C_S) + (0.11)(11.4) + (0.36)(0.33)$$

$$= (0.53)(C_S) + 1.4$$

For Limestone Area

$$\text{Bulk Average Ra-226 (pCi/g)} = (0.47)(C_s) + (0.039)(4.62) + (0.49)(0.49)$$
$$= (0.47)(C_s) + 0.4$$

In order to calculate the 95 percent confidence level, the Student's t distribution was assumed since the number of samples is considered small. The one-sided t_{95} factor was used, appropriate for the degrees of freedom, to apply to the standard error. This product, added to or subtracted from the mean, provides the 95 percent confidence level.

B.4 Ra-226 Bulk Average Factor for the Malpais Exclusion Area

The exemption of the Malpais Exclusion Area from remediation to meet the cleanup standards was originally presented and approved as part of the ARCO Reclamation Plan (ARCO, 1990). Data presented in Appendix C of that plan will be used to derive a particulate and radon source term, consistent with the method presented in Sections B.2 and B.3.

A study was performed to determine the depth to bedrock. Eight study areas were developed in which five measurements of the depth to bedrock were made. A 30-ft by 30-ft grid was established. Rods were driven to the depth of refusal at each corner and at the center. The study showed that the average depth to bedrock was eight inches.

For this analysis, it is assumed that only the top six inches of soil is contaminated (a good assumption) and that the Ra-226 concentration should be adjusted to account for the percentage of lava rock in the top 6-inch layer. In order to calculate the percentage of lava rock in the top 6-inch layer, the data from the previous study were adjusted by changing all measured depths greater than six inches to six inches. The revised data are shown in Table B-6. Using the revised data, the mean depth to bedrock for all measurements was

calculated to be 4.5 inches with a standard error of 0.3 inches. This can be interpreted that on the average, 4.5/6.0 percentage of the top 6-inch layer (15 cm) of the Malpais Exclusion Area is soil with the remaining 25% being rock.

Seven samples of lava rock from the study area resulted in a mean Ra-226 concentration of 4.1 ± 1.3 pCi/g, where the standard error is the standard error at the 95th percent confidence level. A sample taken from an uncontaminated area of the site showed the lava rock background Ra-226 concentration of 1.4 ± 0.55 pCi/g, which is similar to the 1.9 pCi/g that has been established as a site-wide average for soils. In this analysis, 1.9 pCi/g will be used as the naturally occurring background Ra-226 concentration for soil as well as lava.

Sixty-eight samples of surface soils in the Malpais Exclusion Area have been reported in the ARCO Reclamation Plan. The average Ra-226 concentration is 10.6 pCi/g. The standard error at the 95 % confidence level is 2.1 pCi/g.

No data exists to estimate the percentage of rock in the top 6-inch layer of soil. Therefore it will conservatively be assumed to be zero. Using the formula from Section B-3,

$$P_R = (P_r D_r/6) + (6 - D_r)/6$$

where D_r is given in inches.

Since the percentage of loose rock in the top 6-inch layer is assumed to be small,

$$P_R = (6 - 4.5)/6$$
$$= .25$$

The Bulk Average Ra-226 = $(P_S)(C_S) + (P_R)(C_R")$

where P_S and P_R are the soil and rock percentages in the top 6-inch layer and C_S and $C_R"$ are the Ra-226 concentrations in the soil and rock, respectively, calculated at the 95 percent confidence level.

Using the values given above, then the bulk average Ra-226 concentration for the Malpais Exemption Area is:

$$\text{Adjusted Ra-226} = (0.75)(10.6) + (0.25)(5.4)$$
$$= 9.3 \text{ pCi/g}$$

Using 1.9 pCi/g as the background Ra-226 concentration, the bulk average adjusted Ra-226 concentration is 7.4 pCi/g above background.

Table B–1 **Rock–Soil Composition Study for Chinle Sandstone Area**

Formation	Northing	Easting	Depth to Bedrock	Percentage Rock(top 15 cm)
Chinle	33600	25800	3.25	0.16
Chinle	33400	26200	4.00	0.07
Chinle	33400	25400	6.00	0.06
Chinle	32400	27000	2.25	0.00
Chinle	33200	25800	3.00	0.34
Chinle	32600	26600	6.00	0.03
Chinle	32800	26400	6.00	0.06
Chinle	33800	25200	6.00	0.15
Chinle	34200	25400	6.00	0.00
Chinle	33800	25400	1.00	0.46
Chinle	33800	26200	6.00	0.06
Chinle	33600	25600	3.00	0.05
Chinle	33000	25200	2.00	0.13
Chinle	33000	26000	6.00	0.00
Chinle	33200	26600	6.00	0.00
Chinle	33200	27000	6.00	0.00
Chinle	32800	27200	6.00	0.00
Chinle	32400	27800	6.00	0.06
Chinle	31600	27400	6.00	0.00
Chinle	31400	28200	1.50	0.51
Chinle	32000	27600	6.00	0.00
Chinle	34000	25800	1.00	0.20
		Mean	4.50	0.11
		Std Error	0.41	0.03

Table B–2 **Rock–Soil Composition Study for the Lava Area**

Formation	Northing	Easting	Depth to Bedrock	Percentage Rock(top 15 cm)
Lava	29400	23600	2.00	0.07
Lava	30800	23400	6.00	0.00
Lava	30800	22800	3.50	0.52
Lava	30800	22200	5.00	0.11
Lava	30400	22600	6.00	0.53
Lava	30600	24600	5.00	0.06
Lava	27400	24000	2.00	0.26
Lava	27600	24400	2.00	0.21
Lava	29400	24200	3.50	0.00
Lava	32400	21200	6.00	0.43
Lava	31800	21800	6.00	0.03
Lava	31200	22000	6.00	0.11
Lava	30000	21400	0.00	1.00
Lava	30600	23200	0.00	1.00
Lava	30800	24000	4.00	0.41
Lava	30600	25000	4.00	0.13
Lava	27400	23600	6.00	0.06
Lava	27400	24600	2.00	0.27
	Mean		3.83	0.29
	Std Error		0.48	0.07

Table B–3 **Rock–Soil Composition Study for the Limestone Area**

Formation	Northing	Easting	Depth to Bedrock	Percentage Rock(top 15 cm)
Limestone	31800	26000	5.00	0.18
Limestone	31600	26800	6.00	0.04
Limestone	32000	26600	2.00	0.00
Limestone	32000	26400	4.00	0.10
Limestone	32600	25200	3.50	0.04
Limestone	32600	25800	6.00	0.00
Limestone	31400	26400	1.50	0.14
Limestone	31200	25800	6.00	0.02
Limestone	31200	25200	3.00	0.26
Limestone	31600	25400	1.50	0.19
Limestone	32200	25400	6.00	0.00
Limestone	32000	27000	2.50	0.14
Limestone	31100	27400	2.75	0.40
Limestone	31000	27600	1.00	0.02
Limestone	30600	28000	0.00	1.00
Limestone	31600	25200	1.50	0.45
Limestone	31600	25600	0.25	0.00
		Mean	3.09	0.18
		Std Error	0.49	0.06

Table B–4 **Ra–226 Concentrations in Surface Rock for Geological Regions**

Sample Number	Ra–226 Concentration (pCi/g)		
	Lava	Chinle	Limestone
93–3596S	1.5		
93–3610	1.8		
93–3612S	1.0		
93–3613S	23.1		
93–3614S	0.1		
93–3616S	11.2		
93–3617S	–0.9		
93–3595S		1.4	
93–3597S		0.7	
93–3598S		1.6	
93–3603S		–0.2	
93–3604S		0.3	
93–3605S		0.1	
93–3609S		3.9	
93–3611S		4.1	
93–3618S		0.8	
93–3599S			0.6
93–3600S			–1.0
93–3601S			2.7
93–3602S			0.6
93–3606S			9.9
93–3607S			0.9
93–3608S			0.9
Average	5.4	1.4	2.1
Std. Error	3.1	0.5	1.3

Table B–5 **Ra–226 Concentrations in Bed Rock**

Sample Number	Ra–226 Concentration (pCi/g)		
	Lava	Chinle	Limestone
93–2820S	0.2		
93–2827S	0.3		
93–2828S	0.3		
93–2822S		1.3	
93–2823S		0.8	
93–2824S		0.9	
93–2819S			0.5
93–2821S			0.4
93–2825S			0.4
Average	0.27	1.00	0.43
Std. Error	0.02	0.07	0.02

Table B–6 **Depth of Rock in Surface Layer of Malpais Exclusion Area**

	Study Area							
	1	2	3	4	5	6	7	8
Depth (in.)	6.0	6.0	4.0	4.0	6.0	6.0	6.0	6.0
	6.0	1.0	1.0	5.0	3.0	6.0	6.0	6.0
	6.0	0.0	0.5	6.0	6.0	6.0	6.0	6.0
	6.0	0.0	2.0	6.0	6.0	6.0	6.0	6.0
	6.0	0.0	1.0	2.0	6.0	6.0	2.0	6.0
Average	6.0	1.4	1.7	4.6	5.4	6.0	5.2	6.0
Mean	4.5							
Std Error	0.3							

Table B-1 **Rock-Soil Composition Study for Chinle Sandstone Area**

Formation	Northing	Easting	Depth to Bedrock	Percentage Rock(top 15 cm)
Chinle	33600	25800	3.25	0.16
Chinle	33400	26200	4.00	0.07
Chinle	33400	25400	6.00	0.06
Chinle	32400	27000	2.25	0.00
Chinle	33200	25800	3.00	0.34
Chinle	32600	26600	6.00	0.03
Chinle	32800	26400	6.00	0.06
Chinle	33800	25200	6.00	0.15
Chinle	34200	25400	6.00	0.00
Chinle	33800	25400	1.00	0.46
Chinle	33800	26200	6.00	0.06
Chinle	33600	25600	3.00	0.05
Chinle	33000	25200	2.00	0.13
Chinle	33000	26000	6.00	0.00
Chinle	33200	26600	6.00	0.00
Chinle	33200	27000	6.00	0.00
Chinle	32800	27200	6.00	0.00
Chinle	32400	27800	6.00	0.06
Chinle	31600	27400	6.00	0.00
Chinle	31400	28200	1.50	0.51
Chinle	32000	27600	6.00	0.00
Chinle	34000	25800	1.00	0.20
		Mean	4.50	0.11
		Std Error	0.41	0.03

Table B–2 **Rock–Soil Composition Study for the Lava Area**

Formation	Northing	Easting	Depth to Bedrock	Percentage Rock(top 15 cm)
Lava	29400	23600	2.00	0.07
Lava	30800	23400	6.00	0.00
Lava	30800	22800	3.50	0.52
Lava	30800	22200	5.00	0.11
Lava	30400	22600	6.00	0.53
Lava	30600	24600	5.00	0.06
Lava	27400	24000	2.00	0.26
Lava	27600	24400	2.00	0.21
Lava	29400	24200	3.50	0.00
Lava	32400	21200	6.00	0.43
Lava	31800	21800	6.00	0.03
Lava	31200	22000	6.00	0.11
Lava	30000	21400	0.00	1.00
Lava	30600	23200	0.00	1.00
Lava	30800	24000	4.00	0.41
Lava	30600	25000	4.00	0.13
Lava	27400	23600	6.00	0.06
Lava	27400	24600	2.00	0.27
		Mean	3.83	0.29
		Std Error	0.48	0.07

Table B–3 Rock–Soil Composition Study for the Limestone Area

Formation	Northing	Easting	Depth to Bedrock	Percentage Rock(top 15 cm)
Limestone	31800	26000	5.00	0.18
Limestone	31600	26800	6.00	0.04
Limestone	32000	26600	2.00	0.00
Limestone	32000	26400	4.00	0.10
Limestone	32600	25200	3.50	0.04
Limestone	32600	25800	6.00	0.00
Limestone	31400	26400	1.50	0.14
Limestone	31200	25800	6.00	0.02
Limestone	31200	25200	3.00	0.26
Limestone	31600	25400	1.50	0.19
Limestone	32200	25400	6.00	0.00
Limestone	32000	27000	2.50	0.14
Limestone	31100	27400	2.75	0.40
Limestone	31000	27600	1.00	0.02
Limestone	30600	28000	0.00	1.00
Limestone	31600	25200	1.50	0.45
Limestone	31600	25600	0.25	0.00
		Mean	3.09	0.18
		Std Error	0.49	0.06

Table B–4 **Ra–226 Concentrations in Surface Rock for Geological Regions**

Sample Number	Ra–226 Concentration (pCi/g)		
	Lava	Chinle	Limestone
93–3596S	1.5		
93–3610	1.8		
93–3612S	1.0		
93–3613S	23.1		
93–3614S	0.1		
93–3616S	11.2		
93–3617S	–0.9		
93–3595S		1.4	
93–3597S		0.7	
93–3598S		1.6	
93–3603S		–0.2	
93–3604S		0.3	
93–3605S		0.1	
93–3609S		3.9	
93–3611S		4.1	
93–3618S		0.8	
93–3599S			0.6
93–3600S			–1.0
93–3601S			2.7
93–3602S			0.6
93–3606S			9.9
93–3607S			0.9
93–3608S			0.9
Average	5.4	1.4	2.1
Std. Error	3.1	0.5	1.3

Table B–5 **Ra–226 Concentrations in Bed Rock**

Sample Number	Ra–226 Concentration (pCi/g)		
	Lava	Chinle	Limestone
93–2820S	0.2		
93–2827S	0.3		
93–2828S	0.3		
93–2822S		1.3	
93–2823S		0.8	
93–2824S		0.9	
93–2819S			0.5
93–2821S			0.4
93–2825S			0.4
Average	0.27	1.00	0.43
Std. Error	0.02	0.07	0.02

Table B–6 **Depth to Rock in Surface Layer of Malpais Exclusion Area**

	Study Area							
Location*	1	2	3	4	5	6	7	8
Depth (in.)								
	6.0	6.0	4.0	4.0	6.0	6.0	6.0	6.0
	6.0	1.0	1.0	5.0	3.0	6.0	6.0	6.0
	6.0	0.0	0.5	6.0	6.0	6.0	6.0	6.0
	6.0	0.0	2.0	6.0	6.0	6.0	6.0	6.0
	6.0	0.0	1.0	2.0	6.0	6.0	2.0	6.0
Average	6.0	1.4	1.7	4.6	5.4	6.0	5.2	6.0
Mean	4.5							
Std Error	0.3							

* Five measurements were made within each study area

ERG Environmental Restoration Group, Inc.
12809 Arroyo de Vista NE
Albuquerque, New Mexico 87111
(505) 298-4224

Client/Subject ARCO / EXEMPTION REPORT / ROCK STUDY

Prepared by K R BAKER Date 12/15/93

Checked by _____ Date _____

Percentage Rock $P_R = P_{R'} + P_{R''}$

where $P_{R'}$ = % rock in rock/soil matrix

$P_{R''}$ = % bedrock in top 15 cm (6")

$P_{R'} = \frac{P_R D_R}{6}$ where D_R = dept to bedrock (inches)

P_R = percentage rock in rock/soil matrix (use lower 95% CL)

$P_{R''} = \frac{(6 - D_R)}{6}$

Percentile Values for Student t distribution (one-sided)

Formation	Degrees of Freedom	$t_{.95}$
Chinle	20	1.72
Lava	17	1.74
Limestone	16	1.75

For Chinle Sandstone

$P_{R''} = \frac{6 - 4.5}{6} = 0.25$ $\quad P_{R'} = \frac{[(.11 - (1.72)(0.03)](4.5)}{6}$

$= 0.044$

ERG Environmental Restoration Group, Inc.
12809 Arroyo de Vista NE
Albuquerque, New Mexico 87111
(505) 298-4224

Client/Subject ARCO / EXEMPTION REPORT / ROCK STUDY

Prepared by K R BAKER Date 12/15/93

Checked by _____ Date _____

FOR LAVA AREA

$$P_R' = \frac{(3.83'')\left(0.29 - [1.72(0.07)]\right)}{6} = 0.11$$

$$P_R'' = \frac{6 - 3.83}{6} = 0.36$$

FOR Limestone Area

$$P_R' = \frac{\left(0.18 - [1.75][0.04]\right)(3.04)}{6} = 0.039$$

$$P_R'' = \left(6 - \frac{3.04}{6}\right) = 0.49$$

Summary

$$P_R = P_R' + P_R''$$

$P_R = 0.044 + 0.25'' = 0.29$ Chinle Sandstone

$P_R = 0.11 + 0.76 = 0.47$ Lava Area

$P_R = 0.039 + 0.49 = 0.53$ Limestone

ERG Environmental Restoration Group, Inc.
12809 Arroyo de Vista NE
Albuquerque, New Mexico 87111
(505) 298-4224

Client/Subject ARCO / EXEMPTION REPORT / ROCK STUDY

Prepared by K R BAKER Date 12/15/97

Checked by _____ Date _____

ADJUSTED RA-226 FACTORS

$$\text{Adjusted Ra-226} = (1-P_R)C_S + P_{R'}C_{R'} + P_{R''}C_{R''}$$

where C_S = Ra-226 in Soil

$C_{R'}$ = Ra-226 in Rock (upper 95% CL)

$C_{R''}$ = Ra-226 in Bedrock (upper 95% CL)

Student t

$\nu = 2$, $t_{.25} = 2.9$

$\nu = 6$, $t_{.25} = 1.9$

$\nu = 8$, $t_{.25} = 1.86$

For Chinle

$$\text{Adjusted Ra-226} = (0.71)(C_S) + (0.044)(2.3) + (0.25)(1.2)$$
$$= 0.71\,C_S + 0.40$$

For Lava

$$\text{Adjusted Ra-226} = 0.53\,C_S + 0.11(11.41) + 0.36(0.33)$$
$$= 0.53\,C_S + 1.37$$

For Limestone

$$\text{Adjusted Ra-226} = 0.47\,C_S + 0.039(4.62) + 0.49(0.49)$$
$$= 0.47\,C_S + 0.42$$

ERG Environmental Restoration Group, Inc.
12809 Arroyo de Vista NE
Albuquerque, New Mexico 87111
(505) 298-4224

Client/Subject ARCO EXEMPTION REPORT / MALPAIS EXCLUSION

Prepared by J.C.R. BAKER Date 12/15/93

Checked by _____ Date _____

PERCENTAGE ROCK

$$P_R = P_{R'} + P_{R''}$$

$$= \frac{P_{R'} D_R}{6} + \frac{6 - D_R}{6}$$

Assume $P_{R'} = 0$

$$P_R = \frac{6 - 4.5}{6} = 0.25$$

$$\text{Adjusted Ra-226} = 0.75 C_S + 0.25 (C_R)$$

where C_R = upper 95% CL

8 samples rock

$\bar{C} = 4.1 \pm 0.2$

where 0.7 is std error

for $\nu = 7$ Student's t distribution

$t_{.95} = 1.86$

$C_R = 4.1 + 1.3$

$= 5.4$

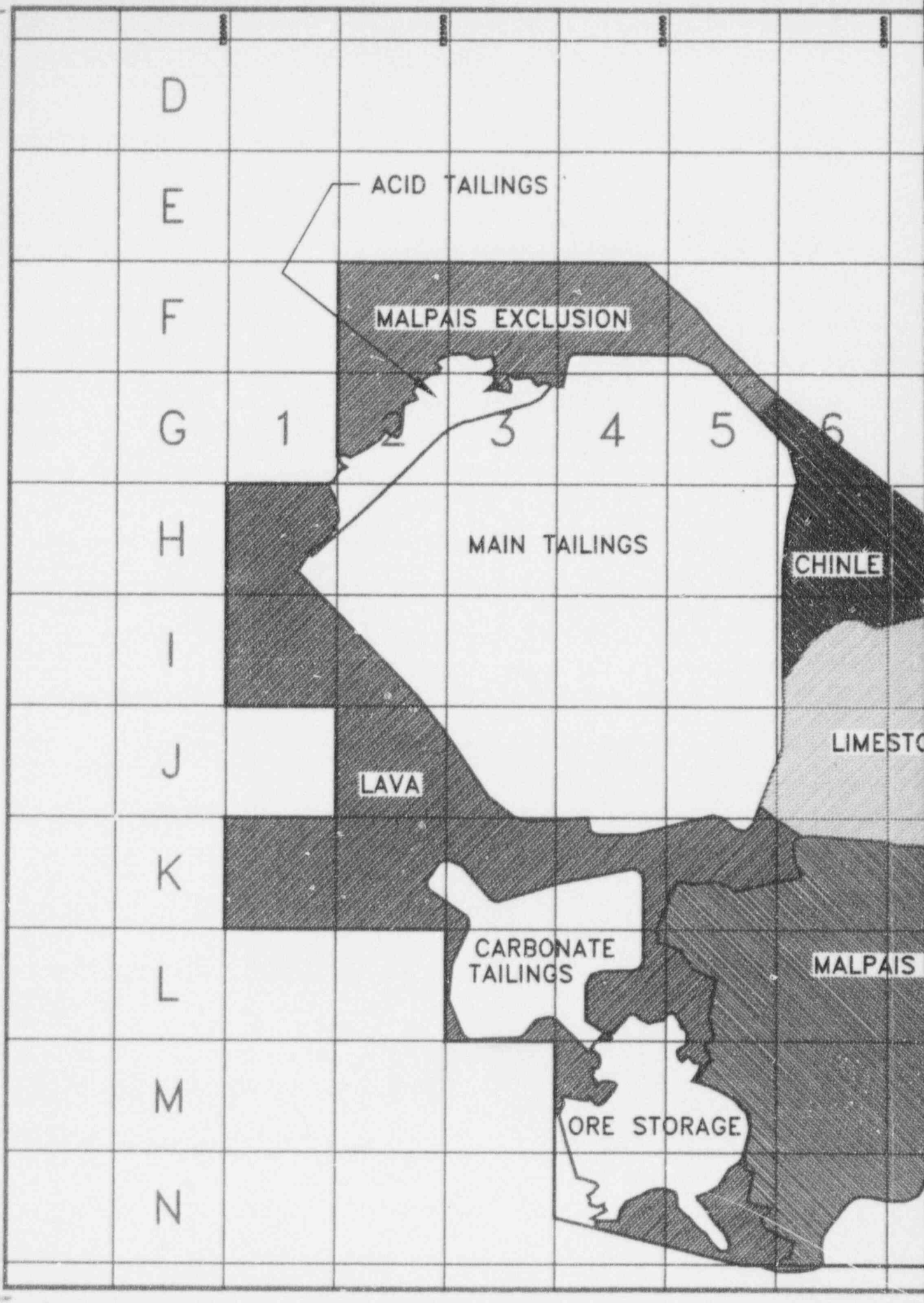
$$\text{Adjusted Ra-226 Concentration} = 0.75 C_S + 0.25 (5.4)$$

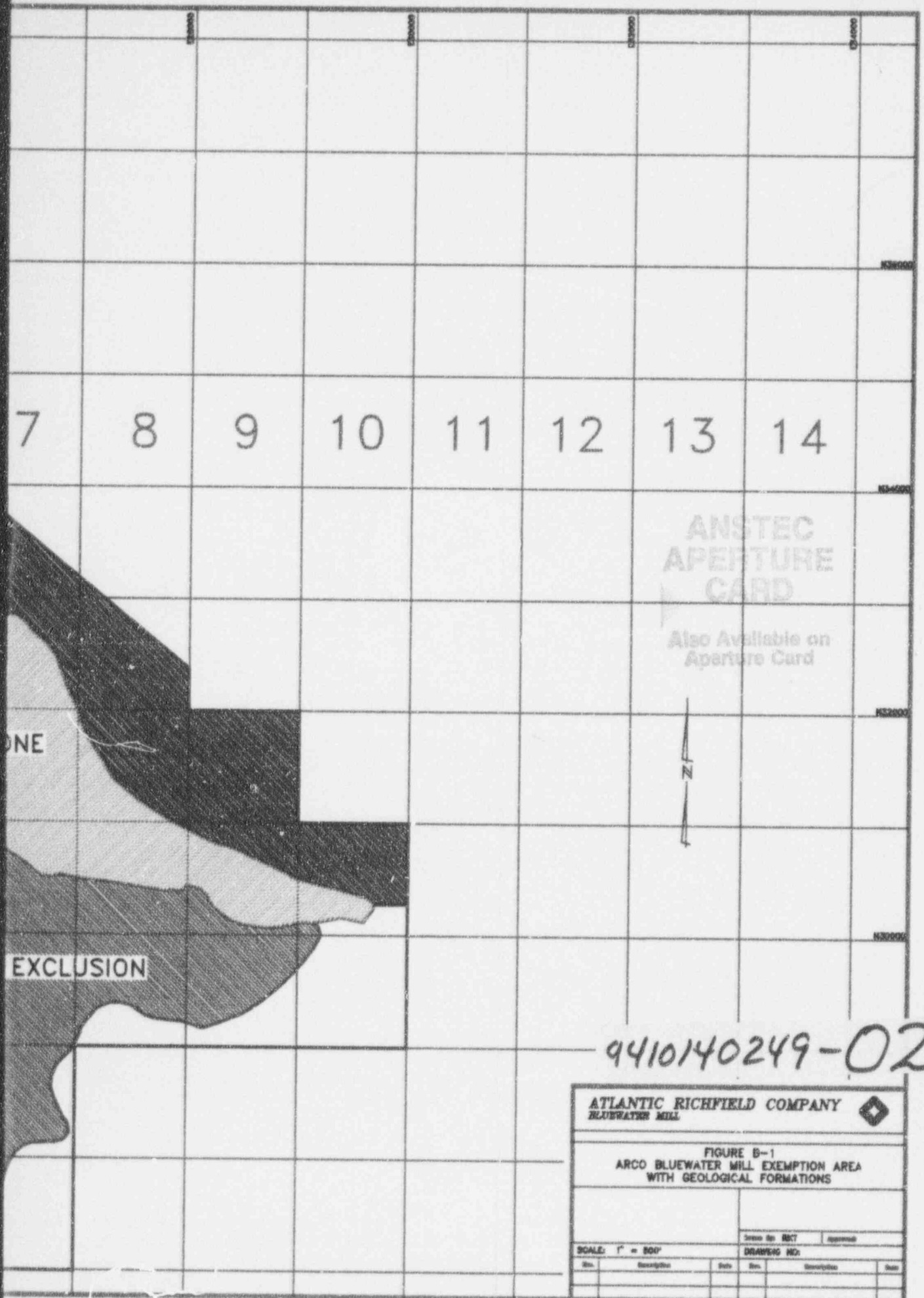
$$= 0.75 C_S + 1.35$$

Mean Ra-226 in Soil was 10.6 pCi/g

$$\text{Adjusted Ra-226} = (0.75)(10.6) + 1.35$$

$$= 9.3 \text{ pCi/g (including background)}$$


D
E
F
G
H
I
J
K
L
M
N
1
2
3
4
5
6
ACID TAILINGS
MALPAIS EXCLUSION
MAIN TAILINGS
CHINLE
LIMESTO
LAVA
CARBONATE
TAILINGS
MALPAIS
ORE STORAGE



9410140249-02

ATLANTIC RICHFIELD COMPANY
BLUEWATER MILL

FIGURE B-1
ARCO BLUEWATER MILL EXEMPTION AREA
WITH GEOLOGICAL FORMATIONS

SCALE: 1" = 800'

Appendix C

CAP88-PC Runs for Particulate Source Term

C A P 8 8 - P C

Version 1.00

Clean Air Act Assessment Package - 1988

G E N E R A L D A T A

Non-Radon Individual Assessment
Dec 23, 1993 1:05 pm

Facility: ARCO Bluewater Mill

Address: P.O. Box 628

City: Grants
State: NM Zip: 87020-0638

Source Category: Uranium Mill Tailings-particulate

Source Type: Area
Emission Year: 94

Comments: For analysis of off-pile remediated site

Dataset Name: PARTICULATE 6
Dataset Date: Dec 23, 1993 1:05 pm
Wind File: WNDFILES\STARANHM.WND

VALUES FOR RADIONUCLIDE-DEPENDENT PARAMETERS

Nuclide	Clearance Class	Particle Size (microns)	Scavenging Coefficient (per second)	Dry Deposition Velocity (m/s)
RN-222	*	0.0	0.00E+00	0.00E+00
RA-226	W	1.0	2.55E-06	1.80E-03
TH-230	Y	1.0	2.55E-06	1.80E-03
U-234	Y	1.0	2.55E-06	1.80E-03
U-238	Y	1.0	2.55E-06	1.80E-03
PA-234	Y	1.0	2.55E-06	1.80E-03
TH-234	Y	1.0	2.55E-06	1.80E-03

VALUES FOR RADIONUCLIDE-DEPENDENT PARAMETERS

Nuclide	DECAY CONSTANT (PER DAY) Radio-active (1)	Surface	Water	TRANSFER COEFFICIENT Milk (2)	Meat (3)
RN-222	1.81E-01	5.48E-05	0.00E+00	0.00E+00	0.00E+00
RA-226	0.00E+00	5.48E-05	0.00E+00	4.50E-04	2.50E-04
TH-230	0.00E+00	5.48E-05	0.00E+00	5.00E-06	6.00E-06
U-234	0.00E+00	5.48E-05	0.00E+00	6.00E-04	2.00E-04
U-238	0.00E+00	5.48E-05	0.00E+00	6.00E-04	2.00E-04
PA-234	2.48E+00	5.48E-05	0.00E+00	5.00E-06	1.00E-05
TH-234	2.88E-02	5.48E-05	0.00E+00	5.00E-06	6.00E-06

FOOTNOTES:
(1) Effective radioactive decay constant in plume; set to zero if less than 1.0E-2

(2) Fraction of animal's daily intake of nuclide which appears in each L of milk (days/L)

(3) Fraction of animal's daily intake of nuclide which appears in each kg of meat (days/kg)

VALUES FOR RADIONUCLIDE-DEPENDENT PARAMETERS

Nuclide	CONCENTRATION UPTAKE FACTOR Forage (1)	Edible (2)	GI UPTAKE FRACTION Inhalation	Ingestion
RN-222	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RA-226	1.50E-02	6.42E-04	2.00E-01	2.00E-01
TH-230	8.50E-04	3.64E-05	2.00E-04	2.00E-04
U-234	8.50E-03	1.71E-03	2.00E-03	2.00E-01
U-238	8.50E-03	1.71E-03	2.00E-03	2.00E-01
PA-234	2.50E-03	1.07E-04	1.00E-03	1.00E-03
TH-234	8.50E-04	3.64E-05	2.00E-04	2.00E-04

FOOTNOTES: (1) Concentration factor for uptake of nuclide from soil for pasture and forage (in pCi/kg dry weight per pCi/kg dry soil)

(2) Concentration factor for uptake of nuclide from soil by edible parts of crops (in pCi/kg wet weight per pCi/kg dry soil)

VALUES FOR RADIONUCLIDE-INDEPENDENT PARAMETERS

HUMAN INHALATION RATE
Cubic centimeters/hr
9.17E+05

SOIL PARAMETERS
Effective surface density (kg/sq m, dry weight)
(Assumes 15 cm plow layer)
2.15E+02

BUILDUP TIMES
For activity in soil (years)
1.00E+02
For radionuclides deposited on ground/water (days)
3.65E+04

DELAY TIMES
Ingestion of pasture grass by animals (hr)
0.00E+00
Ingestion of stored feed by animals (hr)
2.16E+03
Ingestion of leafy vegetables by man (hr)
3.36E 02
Ingestion of produce by man (hr)
3.36E+02
Transport time from animal feed-milk-man (day)
2.00E+00
Time from slaughter to consumption (day)
2.00E+01

WEATHERING
Removal rate constant for physical loss (per hr)
2.90E-03

CROP EXPOSURE DURATION
Pasture grass (hr)
7.20E+02
Crops/leafy vegetables (hr)
1.44E+03

AGRICULTURAL PRODUCTIVITY

Grass-cow-milk-man pathway (kg/sq m)

2.80E-01

Produce/leafy veg for human consumption (kg/sq m)

7.16E-01

FALLOUT INTERCEPTION FRACTIONS

Vegetables

2.00E-01

Pasture

5.70E-01

GRAZING PARAMETERS

Fraction of year animals graze on pasture

4.00E-01

Fraction of daily feed that is pasture grass when animal grazes on pasture

4.30E-01

VALUES FOR RADIONUCLIDE-INDEPENDENT PARAMETERS

ANIMAL FEED CONSUMPTION FACTORS
Contaminated feed/forage (kg/day, dry weight)
1.56E+01

DAIRY PRODUCTIVITY
Milk production of cow (L/day)
1.10E+01

MEAT ANIMAL SLAUGHTER PARAMETERS
Muscle mass of animal at slaughter (kg)
2.00E+02
Fraction of herd slaughtered (per day)
3.81E-03

DECONTAMINATION
Fraction of radioactivity retained after washing
for leafy vegetables and produce
5.00E-01

FRACTIONS GROWN IN GARDEN OF INTEREST
Produce ingested
1.00E+00
Leafy vegetables ingested
1.00E+00

INGESTION RATIOS:
IMMEDIATE SURROUNDING AREA/TOTAL WITHIN AREA
Vegetables
7.00E-01
Meat
4.42E-01
Milk
3.99E-01

MINIMUM INGESTION FRACTIONS FROM OUTSIDE AREA
(Minimum fractions of food types from outside
area listed below are actual fixed values.)

Vegetables
0.00E+00
Meat
0.00E+00
Milk
0.00E+00

HUMAN FOOD UTILIZATION FACTORS
Produce ingestion (kg/y)
1.76E+02
Milk ingestion (L/y)
1.12E+02
Meat ingestion (kg/y)
8.50E+01
Leafy vegetable ingestion (kg/y)
1.80E+01

SWIMMING PARAMETERS
Fraction of time spent swimming
0.00E+00
Dilution factor for water (cm)
1.00E+00

C A P 8 8 - P C

Version 1.00

Clean Air Act Assessment Package - 1988

W E A T H E R D A T A

Non-Radon Individual Assessment
Dec 23, 1993 1:05 pm

Facility: ARCO Bluewater Mill

Address: P.O. Box 628

City: Grants
State: NM Zip: 87020-0638

Source Category: Uranium Mill Tailings-particulate

Source Type: Area
Emission Year: 94

Comments: For analysis of off-pile remediated site

Dataset Name: PARTICULATE 6
Dataset Date: Dec 23, 1993 1:05 pm
Wind File: WNDFILES\STARANHM.WND

HARMONIC AVERAGE WIND SPEEDS (WIND TOWARDS)

Pasquill Stability Class

Wind Dir Frequency	A	B	C	D	E	F	G
N	1.460	1.368	2.071	2.879	1.865	1.346	
0.000	0.057						
NNW	1.247	1.453	2.123	3.377	2.050	1.938	
0.000	0.088						
NW	1.187	1.550	2.041	3.607	2.342	1.541	
0.000	0.086						
WNW	0.000	1.608	1.813	2.359	1.576	1.496	
0.000	0.035						
W	0.000	0.960	1.347	1.861	1.591	1.321	
0.000	0.034						
WSW	0.772	0.960	1.162	1.443	1.431	1.974	
0.000	0.025						
SW	1.187	0.925	0.918	1.160	1.499	1.161	
0.000	0.030						
SSW	1.460	0.988	1.048	1.494	1.441	1.688	
0.000	0.044						
S	2.054	1.164	1.294	1.588	1.476	1.562	
0.000	0.068						
SSE	1.634	1.388	1.585	1.824	1.509	1.985	
0.000	0.095						
SE	1.386	1.637	1.746	2.483	1.600	1.562	
0.000	0.094						
ESE	1.187	1.347	1.685	2.905	1.731	1.371	
0.000	0.075						
E	1.420	1.122	1.665	3.201	1.940	1.938	
0.000	0.090						
ENE	1.091	1.331	2.049	3.172	1.813	1.007	
0.000	0.068						
NE	1.028	1.366	2.103	2.639	1.625	2.572	
0.000	0.073						
NNE	1.261	1.353	1.742	2.286	1.519	0.772	
0.000	0.041						

ARITHMETIC AVERAGE WIND SPEEDS (WIND TOWARDS)

Pasquill Stability Class

Dir	A	B	C	D	E	F	G
N	1.984	1.922	2.821	4.064	2.584	1.870	0.000
NNW	1.752	2.063	3.019	4.352	2.776	2.320	0.000
NW	1.672	2.064	3.184	4.827	3.032	2.056	0.000
WNW	0.000	2.206	2.832	4.084	2.304	2.017	0.000
W	0.000	1.277	2.011	2.914	2.125	1.841	0.000
WSW	0.772	1.277	1.727	2.249	1.989	2.338	0.000
SW	1.672	1.198	1.211	1.805	2.050	1.634	0.000
SSW	1.984	1.335	1.478	2.374	1.994	2.168	0.000
S	2.378	1.744	2.024	2.566	2.074	2.073	0.000
SSE	2.129	1.935	2.324	3.120	2.192	2.344	0.000
SE	1.912	2.203	2.614	4.002	2.329	2.073	0.000
ESE	1.672	1.975	2.550	4.451	2.391	1.896	0.000
E	1.946	1.617	2.601	4.659	2.668	2.320	0.000
ENE	1.525	2.072	3.216	4.452	2.696	1.372	0.000
NE	1.414	2.030	3.115	4.034	2.507	2.572	0.000
NNE	1.769	1.953	2.609	4.070	2.226	0.772	0.000

FREQUENCIES OF STABILITY CLASSES (WIND TOWARDS)

	Pasquill Stability Class					
Dir	A	B	C	D	E	F
G						
N	0.0087	0.0724	0.1649	0.5355	0.2113	0.0072
0.0000						
NNW	0.0102	0.0495	0.1418	0.6017	0.1903	0.0065
0.0000						
NW	0.0037	0.0306	0.0824	0.6073	0.2626	0.0134
0.0000						
WNW	0.0000	0.0356	0.0662	0.4692	0.3672	0.0619
0.0000						
W	0.0000	0.0170	0.0786	0.2918	0.5220	0.0906
0.0000						
WSW	0.0032	0.0227	0.1045	0.3138	0.4545	0.1013
0.0000						
SW	0.0108	0.0940	0.1355	0.2872	0.4092	0.0634
0.0000						
SSW	0.0112	0.0598	0.0955	0.3671	0.4084	0.0580
0.0000						
S	0.0109	0.0515	0.1133	0.4670	0.3354	0.0218
0.0000						
SSE	0.0068	0.0587	0.1296	0.4482	0.3359	0.0208
0.0000						
SE	0.0095	0.0548	0.1287	0.5522	0.2391	0.0157
0.0000						
ESE	0.0088	0.0626	0.1340	0.5495	0.2186	0.0264
0.0000						
E	0.0182	0.0620	0.1550	0.5869	0.1715	0.0063
0.0000						
ENE	0.0145	0.0739	0.1671	0.6527	0.0883	0.0035
0.0000						
NE	0.0157	0.0481	0.1435	0.6704	0.1212	0.0011
0.0000						
NNE	0.0181	0.0762	0.1365	0.5766	0.1887	0.0039
0.0000						
TOT	0.0100	0.0550	0.1280	0.5305	0.2543	0.0222
0.0000						

ADDITIONAL WEATHER INFORMATION

Average Air Temperature:	13.4 degrees C
	286.6 K
Precipitation:	25.5 cm/y
Lid Height:	767 meters
Surface Roughness Length:	0.010 meters
Height Of Wind Measurements:	10.0 meters
Average Wind Speed:	3.214 m/s

Vertical Temperature Gradients:

STABILITY E	0.073 k/m
STABILITY F	0.109 k/m
STABILITY G	0.146 k/m

C A P 8 8 - P C

Version 1.00

Clean Air Act Assessment Package - 1988

DOSE AND RISK EQUIVALENT SUMMARIES

Non-Radon Individual Assessment
Dec 23, 1993 1:48 pm

Facility: ARCO Bluewater Mill

Address: P.O. Box 628

City: Grants
State: NM Zip: 87020-0638

Source Category: Uranium Mill Tailings-particulate

Source Type: Area
Emission Year: 94

Comments: For analysis of off-pile remediated site

Dataset Name: PARTICULATE 4
Dataset Date: Dec 23, 1993 11:22 am
Wind File: WNDFILES\STARANHM.WND

INDIVIDUAL EFFECTIVE DOSE EQUIVALENT RATE (mrem/y)
(All Radionuclides and Pathways)

	Distance (m)					
Direction	2741	2828	2851	2954	3233	2465
2504						
N	3.8E-04	3.7E-04	3.6E-04	3.4E-04	3.0E-04	4.6E-04
4.4E-04						
NNW	5.2E-04	4.9E-04	4.9E-04	4.6E-04	4.0E-04	6.2E-04
6.0E-04						
NW	5.3E-04	5.0E-04	5.0E-04	4.7E-04	4.1E-04	6.3E-04
6.1E-04						
WNW	3.7E-04	3.5E-04	3.5E-04	3.3E-04	2.9E-04	4.4E-04
4.3E-04						
W	4.4E-04	4.2E-04	4.1E-04	3.9E-04	3.4E-04	5.2E-04
5.0E-04						
WSW	3.4E-04	3.3E-04	3.2E-04	3.0E-04	2.7E-04	4.0E-04
3.9E-04						
SW	4.0E-04	3.8E-04	3.7E-04	3.5E-04	3.1E-04	4.7E-04
4.6E-04						
SSW	5.4E-04	5.1E-04	5.1E-04	4.8E-04	4.2E-04	6.4E-04
6.3E-04						
S	7.4E-04	7.0E-04	6.9E-04	6.5E-04	5.7E-04	8.8E-04
8.6E-04						
SSE	9.4E-04	8.9E-04	8.8E-04	8.3E-04	7.2E-04	1.1E-03
1.1E-03						
SE	7.5E-04	7.1E-04	7.0E-04	6.6E-04	5.8E-04	8.9E-04
8.7E-04						
ESE	5.6E-04	5.3E-04	5.2E-04	4.9E-04	4.3E-04	6.6E-04
6.5E-04						
E	5.5E-04	5.2E-04	5.2E-04	4.9E-04	4.2E-04	6.5E-04
6.4E-04						
ENE	3.8E-04	3.6E-04	3.6E-04	3.4E-04	2.9E-04	4.5E-04
4.4E-04						
NE	4.8E-04	4.6E-04	4.5E-04	4.3E-04	3.7E-04	5.7E-04
5.6E-04						
NNE	3.3E-04	3.1E-04	3.1E-04	2.9E-04	2.6E-04	3.9E-04

3.8E-04

	Distance (m)					
Direction	2888	2007	2569	2543	1567	1730
2249						
N	3.5E-04	5.4E-04	4.3E-04	4.3E-04	9.6E-04	8.1E-04
5.3E-04						
NNW	4.8E-04	8.6E-04	5.8E-04	5.9E-04	1.3E-03	1.1E-03
7.2E-04						
NW	4.9E-04	8.8E-04	5.9E-04	6.0E-04	1.3E-03	1.1E-03
7.3E-04						
WNW	3.4E-04	6.1E-04	4.1E-04	4.2E-04	9.1E-04	7.7E-04
5.0E-04						
W	4.0E-04	7.2E-04	4.8E-04	4.9E-04	1.1E-03	9.2E-04
6.0E-04						
WSW	3.1E-04	5.6E-04	3.8E-04	3.8E-04	8.4E-04	7.2E-04
4.7E-04						
SW	3.6E-04	6.6E-04	4.4E-04	4.5E-04	1.0E-03	8.4E-04
5.5E-04						
SSW	5.0E-04	9.0E-04	6.0E-04	6.1E-04	1.4E-03	1.2E-03
7.5E-04						
S	6.8E-04	1.2E-03	8.2E-04	8.3E-04	1.9E-03	1.6E-03
1.0E-03						
SSE	8.6E-04	1.6E-03	1.0E-03	1.1E-03	2.4E-03	2.0E-03
1.3E-03						
SE	6.9E-04	1.3E-03	8.3E-04	8.5E-04	1.9E-03	1.6E-03
1.0E-03						
ESE	5.1E-04	9.3E-04	6.2E-04	6.3E-04	1.4E-03	1.2E-03
7.7E-04						
E	5.0E-04	9.2E-04	6.1E-04	6.2E-04	1.4E-03	1.2E-03
7.6E-04						
ENE	3.5E-04	6.3E-04	4.2E-04	4.3E-04	9.4E-04	8.0E-04
5.2E-04						
NE	4.4E-04	8.0E-04	5.3E-04	5.4E-04	1.2E-03	1.0E-03
6.6E-04						
NNE	3.0E-04	5.4E-04	3.7E-04	3.7E-04	8.2E-04	6.9E-04
4.5E-04						

INDIVIDUAL EFFECTIVE DOSE EQUIVALENT RATE (mrem/y)
(All Radionuclides and Pathways)

	Distance (m)					
Direction	2224	2091	1362	1453	1680	1904
N	5.4E-04	5.9E-04	1.2E-03	1.1E-03	8.5E-04	6.9E-04
NNW	7.3E-04	8.1E-04	1.6E-03	1.5E-03	1.2E-03	9.4E-04
NW	7.4E-04	8.2E-04	1.7E-03	1.5E-03	1.2E-03	9.6E-04
WNW	5.1E-04	5.7E-04	1.1E-03	1.0E-03	8.1E-04	6.6E-04
W	6.1E-04	6.8E-04	1.4E-03	1.2E-03	9.7E-04	7.9E-04
WSW	4.8E-04	5.3E-04	1.1E-03	9.5E-04	7.5E-04	6.1E-04
SW	5.6E-04	6.2E-04	1.3E-03	1.1E-03	8.9E-04	7.2E-04
SSW	7.6E-04	8.4E-04	1.7E-03	1.5E-03	1.2E-03	9.8E-04
S	1.0E-03	1.2E-03	2.4E-03	2.1E-03	1.7E-03	1.3E-03
SSE	1.3E-03	1.5E-03	3.0E-03	2.7E-03	2.1E-03	1.7E-03
SE	1.1E-03	1.2E-03	2.4E-03	2.2E-03	1.7E-03	1.4E-03
ESE	7.8E-04	8.7E-04	1.8E-03	1.6E-03	1.2E-03	1.0E-03
E	7.7E-04	8.6E-04	1.8E-03	1.6E-03	1.2E-03	1.0E-03
ENE	5.3E-04	5.9E-04	1.2E-03	1.1E-03	8.4E-04	6.8E-04
NE	6.8E-04	7.5E-04	1.5E-03	1.4E-03	1.1E-03	8.7E-04
NNE	4.6E-04	5.1E-04	1.0E-03	9.2E-04	7.3E-04	5.9E-04

INDIVIDUAL LIFETIME RISK (deaths)
(All Radionuclides and Pathways)

	Distance (m)					
Direction	2741	2828	2851	2954	3233	2465
2504						
N	3.6E-09	3.4E-09	3.3E-09	3.2E-09	2.8E-09	4.3E-09
4.1E-09						
NNW	4.9E-09	4.6E-09	4.6E-09	4.3E-09	3.7E-09	5.8E-09
5.6E-09						
NW	5.0E-09	4.7E-09	4.6E-09	4.4E-09	3.8E-09	5.9E-09
5.8E-09						
WNW	3.4E-09	3.2E-09	3.2E-09	3.0E-09	2.6E-09	4.1E-09
4.0E-09						
W	4.1E-09	3.9E-09	3.8E-09	3.6E-09	3.1E-09	4.9E-09
4.7E-09						
WSW	3.2E-09	3.0E-09	3.0E-09	2.8E-09	2.4E-09	3.8E-09
3.7E-09						
SW	3.7E-09	3.5E-09	3.5E-09	3.3E-09	2.8E-09	4.4E-09
4.3E-09						
SSW	5.1E-09	4.8E-09	4.7E-09	4.5E-09	3.9E-09	6.0E-09
5.9E-09						
S	7.0E-09	6.6E-09	6.5E-09	6.1E-09	5.3E-09	8.3E-09
8.1E-09						
SSE	8.9E-09	8.4E-09	8.3E-09	7.8E-09	6.8E-09	1.1E-08
1.0E-08						
SE	7.1E-09	6.7E-09	6.6E-09	6.2E-09	5.4E-09	8.5E-09
8.2E-09						
ESE	5.2E-09	5.0E-09	4.9E-09	4.6E-09	4.0E-09	6.2E-09
6.1E-09						
E	5.1E-09	4.9E-09	4.8E-09	4.5E-09	4.0E-09	6.1E-09
6.0E-09						
ENE	3.5E-09	3.3E-09	3.3E-09	3.1E-09	2.7E-09	4.2E-09
4.1E-09						
NE	4.5E-09	4.3E-09	4.2E-09	4.0E-09	3.5E-09	5.4E-09
5.2E-09						
NNE	3.0E-09	2.9E-09	2.9E-09	2.7E-09	2.4E-09	3.6E-09

3.5E-09

	Distance (m)					
Direction	2888	2007	2569	2543	1567	1730
2249						
N	3.3E-09	6.0E-09	4.0E-09	4.0E-09	9.1E-09	7.7E-09
5.0E-09						
NNW	4.5E-09	8.2E-09	5.4E-09	5.5E-09	1.2E-08	1.0E-08
6.8E-09						
NW	4.6E-09	8.3E-09	5.5E-09	5.6E-09	1.3E-08	1.1E-08
6.9E-09						
WNW	3.1E-09	5.7E-09	3.8E-09	3.9E-09	8.6E-09	7.3E-09
4.7E-09						
W	3.7E-09	6.8E-09	4.5E-09	4.6E-09	1.0E-08	8.7E-09
5.6E-09						
WSW	2.9E-09	5.3E-09	3.5E-09	3.6E-09	8.0E-09	6.8E-09
4.4E-09						
SW	3.4E-09	6.2E-09	4.1E-09	4.2E-09	9.4E-09	8.0E-09
5.1E-09						
SSW	4.6E-09	8.5E-09	5.6E-09	5.7E-09	1.3E-08	1.1E-08
7.0E-09						
S	6.4E-09	1.2E-08	7.8E-09	7.9E-09	1.8E-08	1.5E-08
9.7E-09						
SSE	8.1E-09	1.5E-08	9.9E-09	1.0E-08	2.3E-08	1.9E-08
1.2E-08						
SE	6.5E-09	1.2E-08	7.9E-09	8.0E-09	1.8E-08	1.5E-08
9.9E-09						
ESE	4.8E-09	8.8E-09	5.8E-09	5.9E-09	1.3E-08	1.1E-08
7.3E-09						
E	4.7E-09	8.7E-09	5.7E-09	5.8E-09	1.3E-08	1.1E-08
7.2E-09						
ENE	3.2E-09	5.9E-09	3.9E-09	4.0E-09	8.9E-09	7.6E-09
4.9E-09						
NE	4.1E-09	7.6E-09	5.0E-09	5.1E-09	1.1E-08	9.7E-09
6.2E-09						
NNE	2.8E-09	5.1E-09	3.4E-09	3.4E-09	7.7E-09	6.5E-09
4.2E-09						

C A P 8 8 - P C

Version 1.00

Clean Air Act Assessment Package - 1988

DOSE AND RISK EQUIVALENT SUMMARIES

Non-Radon Individual Assessment
Dec 23, 1993 1:03 pm

Facility: ARCO Bluewater Mill

Address: P.O. Box 628

City: Grants
State: NM Zip: 87020-0638

Source Category: Uranium Mill Tailings-particulate

Source Type: Area
Emission Year: 94

Comments: For analysis of off-pile remediated site

Dataset Name: PARTICULATE 5
Dataset Date: Dec 23, 1993 1:03 pm
Wind File: WNDFILES\STARANHM.WND

INDIVIDUAL EFFECTIVE DOSE EQUIVALENT RATE (mrem/y)
(All Radionuclides and Pathways)

	Distance (m)					
Direction	1879	1290	161	988	1085	1175
1198						
N	9.5E-04	1.6E-03	9.1E-02	2.3E-03	2.0E-03	1.8E-03
1.7E-03						
NNW	1.2E-03	2.0E-03	8.8E-02	3.1E-03	2.6E-03	2.3E-03
2.3E-03						
NW	1.2E-03	2.1E-03	9.3E-02	3.1E-03	2.7E-03	2.4E-03
2.3E-03						
WNW	9.2E-04	1.5E-03	9.1E-02	2.2E-03	1.9E-03	1.7E-03
1.7E-03						
W	1.1E-03	1.7E-03	8.7E-02	2.6E-03	2.2E-03	2.0E-03
1.9E-03						
WSW	8.7E-04	1.4E-03	8.9E-02	2.1E-03	1.8E-03	1.6E-03
1.6E-03						
SW	9.8E-04	1.6E-03	1.1E-01	2.4E-03	2.1E-03	1.9E-03
1.8E-03						
SSW	1.2E-03	2.1E-03	1.3E-01	3.2E-03	2.8E-03	2.4E-03
2.4E-03						
S	1.6E-03	2.8E-03	1.5E-01	4.3E-03	3.7E-03	3.3E-03
3.2E-03						
SSE	2.0E-03	3.5E-03	1.5E-01	5.4E-03	4.7E-03	4.1E-03
4.0E-03						
SE	1.6E-03	2.9E-03	1.5E-01	4.4E-03	3.8E-03	3.3E-03
3.2E-03						
ESE	1.3E-03	2.2E-03	1.3E-01	3.3E-03	2.8E-03	2.5E-03
2.4E-03						
E	1.3E-03	2.2E-03	1.1E-01	3.3E-03	2.8E-03	2.5E-03
2.4E-03						
ENE	9.4E-04	1.6E-03	9.5E-02	2.3E-03	2.0E-03	1.8E-03
1.7E-03						
NE	1.1E-03	1.9E-03	8.7E-02	2.9E-03	2.5E-03	2.2E-03
2.1E-03						
NNE	8.5E-04	1.4E-03	8.5E-02	2.0E-03	1.8E-03	1.6E-03

1.5E-03

Direction	istance (m)					
	1296	1585	1560	1293	488	809
852						
N	1.6E-03	1.2E-03	1.2E-03	1.6E-03	8.3E-03	3.3E-03
3.0E-03						
NNW	2.0E-03	1.5E-03	1.6E-03	2.0E-03	1.0E-02	4.3E-03
4.0E-03						
NW	2.1E-03	1.5E-03	1.6E-03	2.1E-03	1.0E-02	4.4E-03
4.0E-03						
WNW	1.5E-03	1.1E-03	1.2E-03	1.5E-03	8.6E-03	3.1E-03
2.8E-03						
W	1.7E-03	1.3E-03	1.3E-03	1.7E-03	8.6E-03	3.7E-03
3.4E-03						
WSW	1.4E-03	1.1E-03	1.1E-03	1.4E-03	7.8E-03	2.9E-03
2.6E-03						
SW	1.6E-03	1.2E-03	1.2E-03	1.6E-03	8.9E-03	3.4E-03
3.1E-03						
SSW	2.1E-03	1.6E-03	1.6E-03	2.1E-03	1.2E-02	4.6E-03
4.2E-03						
S	2.8E-03	2.1E-03	2.1E-03	2.8E-03	1.6E-02	6.2E-03
5.6E-03						
SSE	3.5E-03	2.6E-03	2.6E-03	3.5E-03	1.8E-02	7.8E-03
7.1E-03						
SE	2.9E-03	2.1E-03	2.2E-03	2.9E-03	1.6E-02	6.3E-03
5.7E-03						
ESE	2.2E-03	1.6E-03	1.7E-03	2.2E-03	1.3E-02	4.7E-03
4.3E-03						
E	2.2E-03	1.6E-03	1.6E-03	2.2E-03	1.1E-02	4.6E-03
4.2E-03						
ENE	1.5E-03	1.2E-03	1.2E-03	1.5E-03	9.0E-03	3.2E-03
3.0E-03						
NE	1.9E-03	1.4E-03	1.5E-03	1.9E-03	9.0E-03	4.0E-03
3.7E-03						
NNE	1.4E-03	1.0E-03	1.1E-03	1.4E-03	7.7E-03	2.8E-03
2.6E-03						

INDIVIDUAL EFFECTIVE DOSE EQUIVALENT RATE (mrem/y)
(All Radionuclides and Pathways)

	Distance (m)					
Direction	911	1043	1240	1215	492	520
N	2.6E-03	2.1E-03	1.7E-03	1.7E-03	8.2E-03	7.4E-03
NNW	3.5E-03	2.8E-03	2.2E-03	2.2E-03	1.0E-02	9.2E-03
NW	3.5E-03	2.8E-03	2.2E-03	2.3E-03	1.0E-02	9.2E-03
WNW	2.5E-03	2.0E-03	1.6E-03	1.6E-03	8.4E-03	7.5E-03
W	3.0E-03	2.4E-03	1.8E-03	1.9E-03	8.5E-03	7.7E-03
WSW	2.4E-03	1.9E-03	1.5E-03	1.5E-03	7.7E-03	6.9E-03
SW	2.8E-03	2.2E-03	1.7E-03	1.8E-03	8.8E-03	7.9E-03
SSW	3.7E-03	2.9E-03	2.3E-03	2.3E-03	1.2E-02	1.0E-02
S	5.0E-03	4.0E-03	3.0E-03	3.1E-03	1.6E-02	1.4E-02
SSE	6.3E-03	5.0E-03	3.8E-03	3.9E-03	1.8E-02	1.6E-02
SE	5.0E-03	4.0E-03	3.1E-03	3.2E-03	1.6E-02	1.4E-02
ESE	3.8E-03	3.0E-03	2.3E-03	2.4E-03	1.2E-02	1.1E-02
E	3.8E-03	3.0E-03	2.3E-03	2.4E-03	1.1E-02	9.8E-03
ENE	2.6E-03	2.1E-03	1.6E-03	1.7E-03	8.9E-03	7.9E-03
NE	3.3E-03	2.6E-03	2.0E-03	2.1E-03	8.9E-03	8.1E-03
NNE	2.3E-03	1.9E-03	1.5E-03	1.5E-03	7.5E-03	6.8E-03

INDIVIDUAL LIFETIME RISK (deaths)
(All Radionuclides and Pathways)

Direction	Distance (m) 1879	1290	161	988	1085	1175	1198
N	7.9E-09	1.4E-08	8.8E-07	2.1E-08	1.8E-08	1.6E-08	1.5E-08
NNW	1.0E-08	1.8E-08	8.4E-07	2.8E-08	2.4E-08	2.1E-08	2.1E-08
NW	1.0E-08	1.9E-08	8.9E-07	2.8E-08	2.4E-08	2.2E-08	2.1E-08
WNW	7.6E-09	1.3E-08	8.8E-07	2.0E-08	1.7E-08	1.5E-08	1.5E-08
W	8.8E-09	1.6E-08	8.4E-07	2.4E-08	2.0E-08	1.8E-08	1.7E-08
WSW	7.1E-09	1.2E-08	8.6E-07	1.9E-08	1.6E-08	1.4E-08	1.4E-08
SW	8.1E-09	1.4E-08	1.0E-06	2.2E-08	1.9E-08	1.7E-08	1.6E-08
SSW	1.1E-08	1.9E-08	1.2E-06	2.9E-08	2.5E-08	2.2E-08	2.2E-08
S	1.4E-08	2.6E-08	1.4E-06	4.0E-08	3.4E-08	3.0E-08	2.9E-08
SSE	1.8E-08	3.3E-08	1.5E-06	5.1E-08	4.4E-08	3.8E-08	3.7E-08
SE	1.5E-08	2.6E-08	1.5E-06	4.1E-08	3.5E-08	3.1E-08	3.0E-08
ESE	1.1E-08	2.0E-08	1.3E-06	3.0E-08	2.6E-08	2.3E-08	2.2E-08
E	1.1E-08	2.0E-08	1.1E-06	3.0E-08	2.6E-08	2.3E-08	2.2E-08
ENE	7.8E-09	1.4E-08	9.2E-07	2.1E-08	1.8E-08	1.6E-08	1.5E-08
NE	9.6E-09	1.7E-08	8.4E-07	2.6E-08	2.3E-08	2.0E-08	1.9E-08
NNE	6.9E-09	1.2E-08	8.2E-07	1.8E-08	1.6E-08	1.4E-08	1.4E-08

1.3E-08

Distance (m)

Direction	1296	1585	1560	1293	488	809	852
N	1.4E-08	1.0E-08	1.0E-08	1.4E-08	7.9E-08	3.0E-08	2.7E-08
NNW	1.8E-08	1.3E-08	1.4E-08	1.8E-08	9.8E-08	4.0E-08	3.7E-08
NW	1.8E-08	1.3E-08	1.4E-08	1.8E-08	9.8E-08	4.1E-08	3.7E-08
WNW	1.3E-08	9.6E-09	9.9E-09	1.3E-08	8.1E-08	2.9E-08	2.6E-08
W	1.5E-08	1.1E-08	1.2E-08	1.5E-08	8.1E-08	3.4E-08	3.1E-08
WSW	1.2E-08	9.0E-09	9.2E-09	1.2E-08	7.4E-08	2.7E-08	2.4E-08
SW	1.4E-08	1.0E-08	1.1E-08	1.4E-08	8.4E-08	3.2E-08	2.9E-08
SSW	1.9E-08	1.4E-08	1.4E-08	1.9E-08	1.1E-07	4.3E-08	3.9E-08
S	2.6E-08	1.9E-08	1.9E-08	2.6E-08	1.5E-07	5.8E-08	5.3E-08
SSE	3.3E-08	2.3E-08	2.4E-08	3.3E-08	1.8E-07	7.4E-08	6.7E-08
SE	2.6E-08	1.9E-08	1.9E-08	2.6E-08	1.5E-07	5.9E-08	5.4E-08
ESE	2.0E-08	1.4E-08	1.5E-08	2.0E-08	1.2E-07	4.4E-08	4.0E-08
E	1.9E-08	1.4E-08	1.4E-08	1.9E-08	1.0E-07	4.3E-08	3.9E-08
ENE	1.4E-08	1.0E-08	1.0E-08	1.4E-08	8.5E-08	3.0E-08	2.7E-08
NE	1.7E-08	1.2E-08	1.3E-08	1.7E-08	8.6E-08	3.8E-08	3.4E-08
NNE	1.2E-08	8.8E-09	9.0E-09	1.2E-08	7.3E-08	2.6E-08	2.3E-08

INDIVIDUAL LIFETIME RISK (deaths)
(All Radionuclides and Pathways)

	Distance (m)					
Direction	911	1043	1240	1215	492	520
N	2.4E-08	1.9E-08	1.5E-08	1.5E-08	7.8E-08	7.0E-08
NNW	3.3E-08	2.6E-08	2.0E-08	2.0E-08	9.7E-08	8.7E-08
NW	3.3E-08	2.6E-08	2.0E-08	2.0E-08	9.6E-08	8.7E-08
WNW	2.3E-08	1.8E-08	1.4E-08	1.4E-08	8.0E-08	7.1E-08
W	2.7E-08	2.2E-08	1.6E-08	1.7E-08	8.0E-08	7.3E-08
WSW	2.1E-08	1.7E-08	1.3E-08	1.3E-08	7.3E-08	6.5E-08
SW	2.5E-08	2.0E-08	1.5E-08	1.6E-08	8.3E-08	7.4E-08
SSW	3.4E-08	2.7E-08	2.0E-08	2.1E-08	1.1E-07	9.9E-08
S	4.7E-08	3.7E-08	2.8E-08	2.9E-08	1.5E-07	1.3E-07
SSE	5.9E-08	4.6E-08	3.5E-08	3.6E-08	1.7E-07	1.6E-07
SE	4.7E-08	3.7E-08	2.8E-08	2.9E-08	1.5E-07	1.3E-07
ESE	3.5E-08	2.8E-08	2.1E-08	2.2E-08	1.2E-07	1.1E-07
E	3.5E-08	2.8E-08	2.1E-08	2.1E-08	1.0E-07	9.3E-08
ENE	2.4E-08	1.9E-08	1.5E-08	1.5E-08	8.4E-08	7.5E-08
NE	3.0E-08	2.4E-08	1.8E-08	1.9E-08	8.5E-08	7.7E-08
NNE	2.1E-08	1.7E-08	1.3E-08	1.3E-08	7.1E-08	6.4E-08

C A P 8 8 - P C

Version 1.00

Clean Air Act Assessment Package - 1988

DOSE AND RISK EQUIVALENT SUMMARIES

Non-Radon Individual Assessment
Dec 23, 1993 1:05 pm

Facility: ARCO Bluewater Mill

Address: P.O. Box 628

City: Grants
State: NM Zip: 87020-0638

Source Category: Uranium Mill Tailings-particulate

Source Type: Area
Emission Year: 94

Comments: For analysis of off-pile remediated site

Dataset Name: PARTICULATE 6
Dataset Date: Dec 23, 1993 1:05 pm
Wind File: WNDFILES\STARANHM.WND

INDIVIDUAL EFFECTIVE DOSE EQUIVALENT RATE (mrem/y)
(All Radionuclides and Pathways)

	Distance (m)					
Direction	547	658	74	165	198	274
N	9.7E-03	7.7E-03	4.2E-01	8.7E-02	5.6E-02	2.9E-02
NNW	1.1E-02	9.1E-03	4.2E-01	8.5E-02	5.7E-02	3.3E-02
NW	1.1E-02	9.1E-03	4.2E-01	8.9E-02	5.9E-02	3.2E-02
WNW	9.7E-03	7.6E-03	4.2E-01	8.8E-02	5.8E-02	3.1E-02
W	1.0E-02	8.1E-03	4.2E-01	8.4E-02	5.3E-02	2.7E-02
WSW	9.2E-03	7.3E-03	4.2E-01	8.6E-02	5.5E-02	2.8E-02
SW	1.0E-02	8.0E-03	4.2E-01	1.0E-01	6.2E-02	3.1E-02
SSW	1.2E-02	9.6E-03	4.2E-01	1.2E-01	7.7E-02	3.9E-02
S	1.6E-02	1.2E-02	4.2E-01	1.4E-01	9.2E-02	5.1E-02
SSE	1.8E-02	1.4E-02	4.2E-01	1.4E-01	9.8E-02	5.5E-02
SE	1.6E-02	1.2E-02	4.2E-01	1.4E-01	9.5E-02	5.1E-02
ESE	1.3E-02	9.9E-03	4.2E-01	1.3E-01	8.2E-02	4.2E-02
E	1.2E-02	9.5E-03	4.2E-01	1.1E-01	6.8E-02	3.5E-02
ENE	1.0E-02	7.8E-03	4.2E-01	9.2E-02	6.0E-02	3.2E-02
NE	1.0E-02	8.5E-03	4.2E-01	8.4E-02	5.3E-02	2.8E-02
NNE	9.0E-03	7.2E-03	4.2E-01	8.2E-02	5.3E-02	2.8E-02

INDIVIDUAL LIFETIME RISK (deaths)
(All Radionuclides and Pathways)

	Distance (m)					
Direction	547	658	74	165	198	274
N	7.8E-08	5.9E-08	4.0E-06	8.3E-07	5.2E-07	2.6E-07
NNW	9.4E-08	7.2E-08	4.0E-06	8.0E-07	5.4E-07	3.0E-07
NW	9.4E-08	7.2E-08	4.0E-06	8.5E-07	5.5E-07	3.0E-07
WNW	7.8E-08	5.8E-08	4.0E-06	8.3E-07	5.4E-07	2.8E-07
W	8.1E-08	6.3E-08	4.0E-06	7.9E-07	5.0E-07	2.5E-07
WSW	7.3E-08	5.5E-08	4.0E-06	8.1E-07	5.1E-07	2.6E-07
SW	8.2E-08	6.1E-08	4.0E-06	9.5E-07	5.9E-07	2.8E-07
SSW	1.0E-07	7.7E-08	4.0E-06	1.1E-06	7.3E-07	3.6E-07
S	1.4E-07	1.0E-07	4.0E-06	1.3E-06	8.7E-07	4.7E-07
SSE	1.6E-07	1.2E-07	4.0E-06	1.4E-06	9.3E-07	5.2E-07
SE	1.4E-07	1.0E-07	4.0E-06	1.4E-06	9.0E-07	4.8E-07
ESE	1.1E-07	8.0E-08	4.0E-06	1.2E-06	7.7E-07	3.9E-07
E	1.0E-07	7.6E-08	4.0E-06	1.0E-06	6.4E-07	3.2E-07
ENE	8.2E-08	6.0E-08	4.0E-06	8.7E-07	5.6E-07	3.0E-07
NE	8.5E-08	6.7E-08	4.0E-06	7.9E-07	5.0E-07	2.5E-07
NNE	7.2E-08	5.3E-08	4.0E-06	7.7E-07	4.9E-07	2.5E-07

C A P 8 8 - P C

Version 1.00

Clean Air Act Assessment Package - 1988

DOSE AND RISK EQUIVALENT SUMMARIES

Non-Radon Individual Assessment
Dec 23, 1993 1:05 pm

Facility: ARCO Bluewater Mill

Address: P.O. Box 628

City: Grants
State: NM Zip: 87020-0638

Source Category: Uranium Mill Tailings-particulate

Source Type: Area
Emission Year: 94

Comments: For analysis of off-pile remediated site

Dataset Name: PARTICULATE 6
Dataset Date: Dec 23, 1993 1:05 pm
Wind File: WNDFILES\STARANHM.WND

Appendix D

CAP88-PC Runs for Radon Source Term

C A P 8 8 - P C

Version 1.00

Clean Air Act Assessment Package - 1988

G E N E R A L D A T A

Radon Individual Assessment
Dec 23, 1993 1:09 pm

Facility: ARCO Bluewater Mill

Address: P.O. Box 628

City: Grants
State: NM Zip: 87020-0638

Source Category: Uranium Mill Tailings-particulate

Source Type: Area
Emission Year: 94

Comments: For analysis of off-pile remediated site

Dataset Name: RADON 5
Dataset Date: Dec 23, 1993 1:09 pm
Wind File: WNDFILES\STARANHM.WND

VALUES FOR RADIONUCLIDE-DEPENDENT PARAMETERS

Nuclide	Clearance Class	Particle Size (microns)	Scavenging Coefficient (per second)	Dry Deposition Velocity (m/s)
RN-222	*	0.0	0.00E+00	0.00E+00

VALUES FOR RADIONUCLIDE-DEPENDENT PARAMETERS

Nuclide	DECAY CONSTANT (PER DAY) Radio-active (1)	Surface	Water	TRANSFER COEFFICIENT Milk (2)	Meat (3)
RN-222	1.81E-01	5.48E-05	0.00E+00	0.00E+00	0.00E+00

FOOTNOTES:
(1) Effective radioactive decay constant in plume; set to zero if less than 1.0E-2

(2) Fraction of animal's daily intake of nuclide which appears in each L of milk (days/L)

(3) Fraction of animal's daily intake of nuclide which appears in each kg of meat (days/kg)

VALUES FOR RADIONUCLIDE-DEPENDENT PARAMETERS

Nuclide	CONCENTRATION UPTAKE FACTOR Forage (1)	Edible (2)	GI UPTAKE FRACTION Inhalation	Ingestion
RN-222	0.00E+00	0.00E+00	0.00E+00	0.00E+00

FOOTNOTES: (1) Concentration factor for uptake of nuclide from soil for pasture and forage (in pCi/kg dry weight per pCi/kg dry soil)

(2) Concentration factor for uptake of nuclide from soil by edible parts of crops (in pCi/kg wet weight per pCi/kg dry soil)

VALUES FOR RADIONUCLIDE-INDEPENDENT PARAMETERS

HUMAN INHALATION RATE
Cubic centimeters/hr
9.17E+05

SOIL PARAMETERS
Effective surface density (kg/sq m, dry weight)
(Assumes 15 cm plow layer)
2.15E+02

BUILDUP TIMES
For activity in soil (years)
1.00E+02
For radionuclides deposited on ground/water (days)
3.65E+04

DELAY TIMES
Ingestion of pasture grass by animals (hr)
0.00E+00
Ingestion of stored feed by animals (hr)
2.16E+03
Ingestion of leafy vegetables by man (hr)
3.36E+02
Ingestion of produce by man (hr)
3.36E+02
Transport time from animal feed-milk-man (day)
2.00E+00
Time from slaughter to consumption (day)
2.00E+01

WEATHERING
Removal rate constant for physical loss (per hr)
2.90E-03

CROP EXPOSURE DURATION
Pasture grass (hr)
7.20E+02
Crops/leafy vegetables (hr)
1.44E+03

AGRICULTURAL PRODUCTIVITY

Grass-cow-milk-man pathway (kg/sq m)

2.80E-01

Produce/leafy veg for human consumption (kg/sq m)

7.16E-01

FALLOUT INTERCEPTION FRACTIONS

Vegetables

2.00E-01

Pasture

5.70E-01

GRAZING PARAMETERS

Fraction of year animals graze on pasture

4.00E-01

Fraction of daily feed that is pasture grass when animal grazes on pasture

4.30E-01

VALUES FOR RADIONUCLIDE-INDEPENDENT PARAMETERS

ANIMAL FEED CONSUMPTION FACTORS
Contaminated feed/forage (kg/day, dry weight)
1.56E+01

DAIRY PRODUCTIVITY
Milk production of cow (L/day)
1.10E+01

MEAT ANIMAL SLAUGHTER PARAMETERS
Muscle mass of animal at slaughter (kg)
2.00E+02
Fraction of herd slaughtered (per day)
3.81E-03

DECONTAMINATION
Fraction of radioactivity retained after washing
for leafy vegetables and produce
5.00E-01

FRACTIONS GROWN IN GARDEN OF INTEREST
Produce ingested
1.00E+00
Leafy vegetables ingested
1.00E+00

INGESTION RATIOS:
IMMEDIATE SURROUNDING AREA/TOTAL WITHIN AREA
Vegetables
7.00E-01
Meat
4.42E-01
Milk
3.99E-01

MINIMUM INGESTION FRACTIONS FROM OUTSIDE AREA
(Minimum fractions of food types from outside
area listed below are actual fixed values.)

Vegetables
0.00E+00
Meat
0.00E+00
Milk
0.00E+00

HUMAN FOOD UTILIZATION FACTORS
Produce ingestion (kg/y)
1.76E+02
Milk ingestion (L/y)
1.12E+02
Meat ingestion (kg/y)
8.50E+01
Leafy vegetable ingestion (kg/y)
1.80E+01

SWIMMING PARAMETERS
Fraction of time spent swimming
0.00E+00
Dilution factor for water (cm)
1.00E+00

C A P 8 8 - P C

Version 1.00

Clean Air Act Assessment Package - 1988

DOSE AND RISK EQUIVALENT SUMMARIES

Radon Individual Assessment
Dec 23, 1993 12:59 am

Facility: ARCO Bluewater Mill

Address: P.O. Box 628

City: Grants
State: NM Zip: 87020-0638

Source Category: Uranium Mill Tailings-particulate

Source Type: Area
Emission Year: 94

Comments: For analysis of off-pile remediated site

Dataset Name: RADON 4
Dataset Date: Dec 23, 1993 12:59 am
Wind File: WNDFILES\STARANHM.WND

INDIVIDUAL EFFECTIVE DOSE EQUIVALENT RATE (mrem/y)
(All Radionuclides and Pathways)

	Distance (m)					
Direction	2741	2828	2851	2954	3233	2465
2504						
N	7.9E-05	7.5E-05	7.4E-05	7.0E-05	6.1E-05	9.5E-05
9.2E-05						
NNW	1.1E-04	1.0E-04	1.0E-04	9.5E-05	8.3E-05	1.3E-04
1.3E-04						
NW	1.1E-04	1.0E-04	1.0E-04	9.7E-05	8.5E-05	1.3E-04
1.3E-04						
WNW	8.0E-05	7.6E-05	7.5E-05	7.1E-05	6.2E-05	9.5E-05
9.3E-05						
W	9.8E-05	9.3E-05	9.2E-05	8.7E-05	7.6E-05	1.2E-04
1.1E-04						
WSW	7.4E-05	7.1E-05	7.0E-05	6.6E-05	5.8E-05	8.9E-05
8.6E-05						
SW	8.9E-05	8.5E-05	8.4E-05	7.9E-05	6.9E-05	1.1E-04
1.0E-04						
SSW	1.2E-04	1.1E-04	1.1E-04	1.1E-04	9.3E-05	1.4E-04
1.4E-04						
S	1.6E-04	1.6E-04	1.5E-04	1.5E-04	1.3E-04	2.0E-04
1.9E-04						
SSE	2.1E-04	2.0E-04	2.0E-04	1.8E-04	1.6E-04	2.5E-04
2.4E-04						
SE	1.6E-04	1.5E-04	1.5E-04	1.4E-04	1.3E-04	1.9E-04
1.9E-04						
ESE	1.2E-04	1.1E-04	1.1E-04	1.1E-04	9.2E-05	1.4E-04
1.4E-04						
E	1.1E-04	1.1E-04	1.1E-04	1.0E-04	8.7E-05	1.4E-04
1.3E-04						
ENE	7.7E-05	7.3E-05	7.2E-05	6.8E-05	5.9E-05	9.2E-05
8.9E-05						
NE	1.0E-04	9.5E-05	9.3E-05	8.8E-05	7.6E-05	1.2E-04
1.2E-04						
NNE	6.9E-05	6.5E-05	6.4E-05	6.0E-05	5.3E-05	8.2E-05

8.0E-05

	Distance (m)					
Direction	2888	2007	2569	2543	1567	1730
2249						
N	7.3E-05	1.3E-04	8.8E-05	9.0E-05	2.0E-04	1.7E-04
1.1E-04						
NNW	9.8E-05	1.8E-04	1.2E-04	1.2E-04	2.7E-04	2.3E-04
1.5E-04						
NW	1.0E-04	1.9E-04	1.2E-04	1.2E-04	2.8E-04	2.4E-04
1.5E-04						
WNW	7.3E-05	1.3E-04	8.9E-05	9.0E-05	2.0E-04	1.7E-04
1.1E-04						
W	9.0E-05	1.6E-04	1.1E-04	1.1E-04	2.5E-04	2.1E-04
1.4E-04						
WSW	6.8E-05	1.2E-04	8.3E-05	8.4E-05	1.9E-04	1.6E-04
1.0E-04						
SW	8.2E-05	1.5E-04	1.0E-04	1.0E-04	2.3E-04	1.9E-04
1.2E-04						
SSW	1.1E-04	2.0E-04	1.3E-04	1.4E-04	3.1E-04	2.6E-04
1.7E-04						
S	1.5E-04	2.8E-04	1.8E-04	1.9E-04	4.2E-04	3.5E-04
2.3E-04						
SSE	1.9E-04	3.5E-04	2.3E-04	2.4E-04	5.3E-04	4.5E-04
2.9E-04						
SE	1.5E-04	2.7E-04	1.8E-04	1.8E-04	4.1E-04	3.5E-04
2.3E-04						
ESE	1.1E-04	2.0E-04	1.3E-04	1.4E-04	3.1E-04	2.6E-04
1.7E-04						
E	1.0E-04	1.9E-04	1.3E-04	1.3E-04	2.9E-04	2.5E-04
1.6E-04						
ENE	7.0E-05	1.3E-04	8.6E-05	8.7E-05	2.0E-04	1.7E-04
1.1E-04						
NE	9.1E-05	1.7E-04	1.1E-04	1.1E-04	2.6E-04	2.2E-04
1.4E-04						
NNE	6.3E-05	1.2E-04	7.6E-05	7.8E-05	1.8E-04	1.5E-04
9.6E-05						

INDIVIDUAL EFFECTIVE DOSE EQUIVALENT RATE (mrem/y)
(All Radionuclides and Pathways)

	Distance (m)					
Direction	2224	2091	1362	1453	1680	1904
N	1.1E-04	1.2E-04	2.6E-04	2.3E-04	1.8E-04	1.5E-04
NNW	1.5E-04	1.7E-04	3.5E-04	3.1E-04	2.4E-04	2.0E-04
NW	1.6E-04	1.7E-04	3.5E-04	3.2E-04	2.5E-04	2.0E-04
WNW	1.1E-04	1.2E-04	2.5E-04	2.3E-04	1.8E-04	1.5E-04
W	1.4E-04	1.5E-04	3.1E-04	2.8E-04	2.2E-04	1.8E-04
WSW	1.1E-04	1.2E-04	2.4E-04	2.1E-04	1.7E-04	1.4E-04
SW	1.3E-04	1.4E-04	2.9E-04	2.6E-04	2.0E-04	1.6E-04
SSW	1.7E-04	1.9E-04	3.9E-04	3.5E-04	2.7E-04	2.2E-04
S	2.3E-04	2.6E-04	5.3E-04	4.7E-04	3.7E-04	3.0E-04
SSE	3.0E-04	3.3E-04	6.7E-04	6.0E-04	4.7E-04	3.8E-04
SE	2.3E-04	2.6E-04	5.2E-04	4.7E-04	3.7E-04	3.0E-04
ESE	1.7E-04	1.9E-04	3.9E-04	3.5E-04	2.7E-04	2.2E-04
E	1.6E-04	1.8E-04	3.7E-04	3.3E-04	2.6E-04	2.1E-04
ENE	1.1E-04	1.2E-04	2.5E-04	2.2E-04	1.8E-04	1.4E-04
NE	1.4E-04	1.6E-04	3.2E-04	2.9E-04	2.3E-04	1.8E-04
NNE	9.7E-05	1.1E-04	2.2E-04	2.0E-04	1.6E-04	1.3E-04

INDIVIDUAL LIFETIME RISK (deaths)
(All Radionuclides and Pathways)

	Distance (m)					
Direction	2741	2828	2851	2954	3233	2465
2504						
N	1.9E-08	1.8E-08	1.8E-08	1.7E-08	1.5E-08	2.2E-08
2.2E-08						
NNW	2.6E-08	2.5E-08	2.4E-08	2.3E-08	2.1E-08	3.0E-08
3.0E-08						
NW	2.7E-08	2.5E-08	2.5E-08	2.4E-08	2.1E-08	3.1E-08
3.0E-08						
WNW	1.9E-08	1.8E-08	1.8E-08	1.7E-08	1.5E-08	2.2E-08
2.2E-08						
W	2.4E-08	2.3E-08	2.2E-08	2.1E-08	1.9E-08	2.8E-08
2.7E-08						
WSW	1.8E-08	1.7E-08	1.7E-08	1.6E-08	1.4E-08	2.1E-08
2.0E-08						
SW	2.2E-08	2.1E-08	2.0E-08	1.9E-08	1.7E-08	2.5E-08
2.5E-08						
SSW	2.9E-08	2.8E-08	2.8E-08	2.6E-08	2.3E-08	3.4E-08
3.3E-08						
S	4.0E-08	3.8E-08	3.7E-08	3.6E-08	3.2E-08	4.6E-08
4.5E-08						
SSE	5.0E-08	4.8E-08	4.7E-08	4.5E-08	4.0E-08	5.9E-08
5.7E-08						
SE	3.9E-08	3.8E-08	3.7E-08	3.5E-08	3.1E-08	4.6E-08
4.5E-08						
ESE	2.9E-08	2.8E-08	2.7E-08	2.6E-08	2.3E-08	3.4E-08
3.3E-08						
E	2.8E-08	2.6E-08	2.6E-08	2.5E-08	2.2E-08	3.2E-08
3.1E-08						
ENE	1.8E-08	1.8E-08	1.7E-08	1.7E-08	1.5E-08	2.2E-08
2.1E-08						
NE	2.4E-08	2.3E-08	2.3E-08	2.2E-08	1.9E-08	2.8E-08
2.7E-08						
NNE	1.7E-08	1.6E-08	1.6E-08	1.5E-08	1.3E-08	1.9E-08

1.9E-08

Direction	Distance (m)					
	2888	2007	2569	2543	1567	1730
2249						
N	1.8E-08	3.0E-08	2.1E-08	2.1E-08	4.4E-08	3.8E-08
2.6E-08						
NNW	2.4E-08	4.1E-08	2.8E-08	2.9E-08	6.0E-08	5.1E-08
3.5E-08						
NW	2.5E-08	4.2E-08	2.9E-08	3.0E-08	6.1E-08	5.2E-08
3.5E-08						
WNW	1.8E-08	3.0E-08	2.1E-08	2.1E-08	4.4E-08	3.8E-08
2.6E-08						
W	2.2E-08	3.7E-08	2.6E-08	2.6E-08	5.4E-08	4.6E-08
3.1E-08						
WSW	1.7E-08	2.8E-08	2.0E-08	2.0E-08	4.1E-08	3.5E-08
2.4E-08						
SW	2.0E-08	3.4E-08	2.4E-08	2.4E-08	5.0E-08	4.3E-08
2.9E-08						
SSW	2.7E-08	4.6E-08	3.2E-08	3.2E-08	6.7E-08	5.7E-08
3.9E-08						
S	3.7E-08	6.3E-08	4.4E-08	4.4E-08	9.1E-08	7.8E-08
5.3E-08						
SSE	4.7E-08	7.9E-08	5.5E-08	5.6E-08	1.2E-07	9.9E-08
6.7E-08						
SE	3.6E-08	6.2E-08	4.3E-08	4.4E-08	9.0E-08	7.8E-08
5.2E-08						
ESE	2.7E-08	4.6E-08	3.2E-08	3.2E-08	6.7E-08	5.7E-08
3.9E-08						
E	2.6E-08	4.4E-08	3.0E-08	3.1E-08	6.4E-08	5.5E-08
3.7E-08						
ENE	1.7E-08	2.9E-08	2.0E-08	2.1E-08	4.3E-08	3.7E-08
2.5E-08						
NE	2.2E-08	3.8E-08	2.6E-08	2.7E-08	5.6E-08	4.8E-08
3.2E-08						
NNE	1.5E-08	2.6E-08	1.8E-08	1.8E-08	3.8E-08	3.3E-08
2.2E-08						

C A P 8 8 - P C

Version 1.00

Clean Air Act Assessment Package - 1988

DOSE AND RISK EQUIVALENT SUMMARIES

Radon Individual Assessment
Dec 23, 1993 1:09 pm

Facility: ARCO Bluewater Mill

Address: P.O. Box 628

City: Grants
State: NM Zip: 87020-0638

Source Category: Uranium Mill Tailings-RADON

Source Type: Area
Emission Year: 94

Comments: For analysis of off-pile remediated site

Dataset Name: RADON 5
Dataset Date: Dec 23, 1993 1:09 pm
Wind File: WNDFILES\STARANHM.WND

INDIVIDUAL EFFECTIVE DOSE EQUIVALENT RATE (mrem/y)
(All Radionuclides and Pathways)

	Distance (m)					
Direction	1879	1290	161	988	1085	1175
1198						
N	1.5E-04	2.8E-04	1.9E-02	4.4E-04	3.8E-04	3.3E-04
3.2E-04						
NNW	2.0E-04	3.8E-04	1.8E-02	6.0E-04	5.1E-04	4.5E-04
4.3E-04						
NW	2.1E-04	3.9E-04	1.9E-02	6.0E-04	5.2E-04	4.5E-04
4.4E-04						
WNW	1.5E-04	2.8E-04	1.9E-02	4.3E-04	3.7E-04	3.2E-04
3.1E-04						
W	1.8E-04	3.4E-04	1.8E-02	5.3E-04	4.5E-04	4.0E-04
3.8E-04						
WSW	1.4E-04	2.6E-04	1.9E-02	4.0E-04	3.5E-04	3.0E-04
2.9E-04						
SW	1.7E-04	3.1E-04	2.2E-02	4.9E-04	4.2E-04	3.7E-04
3.6E-04						
SSW	2.3E-04	4.2E-04	2.7E-02	6.6E-04	5.6E-04	4.9E-04
4.8E-04						
S	3.1E-04	5.8E-04	3.1E-02	9.0E-04	7.7E-04	6.8E-04
6.5E-04						
SSE	3.9E-04	7.3E-04	3.2E-02	1.1E-03	9.8E-04	8.5E-04
8.3E-04						
SE	3.1E-04	5.7E-04	3.2E-02	9.0E-04	7.7E-04	6.7E-04
6.5E-04						
ESE	2.3E-04	4.2E-04	2.8E-02	6.6E-04	5.6E-04	4.9E-04
4.8E-04						
E	2.2E-04	4.1E-04	2.4E-02	6.4E-04	5.5E-04	4.8E-04
4.6E-04						
ENE	1.5E-04	2.7E-04	2.0E-02	4.3E-04	3.7E-04	3.2E-04
3.1E-04						
NE	1.9E-04	3.5E-04	1.8E-02	5.6E-04	4.7E-04	4.1E-04
4.0E-04						
NNE	1.3E-04	2.4E-04	1.8E-02	3.8E-04	3.2E-04	2.8E-04

2.7E-04

	Distance (m)					
Direction	1296	1585	1560	1293	488	809
852						
N	2.8E-04	2.0E-04	2.0E-04	2.8E-04	1.7E-03	6.4E-04
5.8E-04						
NNW	3.8E-04	2.7E-04	2.8E-04	3.8E-04	2.1E-03	8.7E-04
7.9E-04						
NW	3.8E-04	2.7E-04	2.8E-04	3.9E-04	2.1E-03	8.8E-04
8.0E-04						
WNW	2.8E-04	2.0E-04	2.0E-04	2.8E-04	1.8E-03	6.3E-04
5.7E-04						
W	3.4E-04	2.4E-04	2.5E-04	3.4E-04	1.8E-03	7.7E-04
7.0E-04						
WSW	2.6E-04	1.8E-04	1.9E-04	2.6E-04	1.7E-03	5.9E-04
5.3E-04						
SW	3.1E-04	2.2E-04	2.3E-04	3.1E-04	1.9E-03	7.2E-04
6.5E-04						
SSW	4.2E-04	3.0E-04	3.1E-04	4.2E-04	2.5E-03	9.6E-04
8.7E-04						
S	5.7E-04	4.1E-04	4.2E-04	5.8E-04	3.4E-03	1.3E-03
1.2E-03						
SSE	7.3E-04	5.2E-04	5.3E-04	7.3E-04	3.9E-03	1.7E-03
1.5E-03						
SE	5.7E-04	4.1E-04	4.2E-04	5.7E-04	3.4E-03	1.3E-03
1.2E-03						
ESE	4.2E-04	3.0E-04	3.1E-04	4.2E-04	2.6E-03	9.6E-04
8.7E-04						
E	4.0E-04	2.9E-04	3.0E-04	4.1E-04	2.3E-03	9.3E-04
8.5E-04						
ENE	2.7E-04	1.9E-04	2.0E-04	2.7E-04	1.8E-03	6.3E-04
5.7E-04						
NE	3.5E-04	2.5E-04	2.6E-04	3.5E-04	1.9E-03	8.1E-04
7.3E-04						
NNE	2.4E-04	1.7E-04	1.8E-04	2.4E-04	1.6E-03	5.5E-04
5.0E-04						

INDIVIDUAL EFFECTIVE DOSE EQUIVALENT RATE (mrem/y)
(All Radionuclides and Pathways)

	Distance (m)					
Direction	911	1043	1240	1215	492	520
N	5.1E-04	4.0E-04	3.0E-04	3.1E-04	1.7E-03	1.5E-03
NNW	6.9E-04	5.4E-04	4.1E-04	4.2E-04	2.1E-03	1.9E-03
NW	7.0E-04	5.5E-04	4.1E-04	4.3E-04	2.1E-03	1.9E-03
WNW	5.0E-04	3.9E-04	3.0E-04	3.1E-04	1.8E-03	1.6E-03
W	6.1E-04	4.8E-04	3.6E-04	3.8E-04	1.8E-03	1.6E-03
WSW	4.7E-04	3.7E-04	2.8E-04	2.9E-04	1.6E-03	1.5E-03
SW	5.7E-04	4.5E-04	3.4E-04	3.5E-04	1.9E-03	1.7E-03
SSW	7.7E-04	6.0E-04	4.5E-04	4.7E-04	2.5E-03	2.2E-03
S	1.0E-03	8.2E-04	6.2E-04	6.4E-04	3.3E-03	3.0E-03
SSE	1.3E-03	1.0E-03	7.8E-04	8.1E-04	3.9E-03	3.5E-03
SE	1.0E-03	8.2E-04	6.1E-04	6.3E-04	3.3E-03	3.0E-03
ESE	7.7E-04	6.0E-04	4.5E-04	4.7E-04	2.6E-03	2.3E-03
E	7.4E-04	5.8E-04	4.4E-04	4.5E-04	2.2E-03	2.0E-03
ENE	5.0E-04	3.9E-04	2.9E-04	3.0E-04	1.8E-03	1.6E-03
NE	6.4E-04	5.1E-04	3.8E-04	3.9E-04	1.8E-03	1.7E-03
NNE	4.4E-04	3.5E-04	2.6E-04	2.7E-04	1.6E-03	1.4E-03

INDIVIDUAL LIFETIME RISK (deaths)
(All Radionuclides and Pathways)

	Distance (m)					
Direction	1879	1290	161	988	1085	1175
1198						
N	3.3E-08	5.9E-08	3.5E-06	9.0E-08	7.7E-08	6.8E-08
6.6E-08						
NNW	4.5E-08	8.0E-08	3.4E-06	1.2E-07	1.0E-07	9.2E-08
9.0E-08						
NW	4.6E-08	8.1E-08	3.6E-06	1.2E-07	1.1E-07	9.4E-08
9.1E-08						
WNW	3.3E-08	5.8E-08	3.5E-06	8.8E-08	7.6E-08	6.7E-08
6.5E-08						
W	4.1E-08	7.1E-08	3.4E-06	1.1E-07	9.3E-08	8.2E-08
8.0E-08						
WSW	3.1E-08	5.4E-08	3.5E-06	8.2E-08	7.1E-08	6.3E-08
6.1E-08						
SW	3.7E-08	6.6E-08	4.1E-06	1.0E-07	8.6E-08	7.6E-08
7.4E-08						
SSW	5.0E-08	8.9E-08	5.0E-06	1.3E-07	1.2E-07	1.0E-07
9.9E-08						
S	6.9E-08	1.2E-07	5.7E-06	1.8E-07	1.6E-07	1.4E-07
1.4E-07						
SSE	8.7E-08	1.5E-07	5.9E-06	2.3E-07	2.0E-07	1.8E-07
1.7E-07						
SE	6.8E-08	1.2E-07	5.9E-06	1.8E-07	1.6E-07	1.4E-07
1.4E-07						
ESE	5.0E-08	8.9E-08	5.2E-06	1.3E-07	1.2E-07	1.0E-07
1.0E-07						
E	4.8E-08	8.6E-08	4.4E-06	1.3E-07	1.1E-07	9.9E-08
9.6E-08						
ENE	3.2E-08	5.8E-08	3.7E-06	8.8E-08	7.6E-08	6.7E-08
6.5E-08						
NE	4.2E-08	7.4E-08	3.3E-06	1.1E-07	9.7E-08	8.6E-08
8.4E-08						
NNE	2.9E-08	5.1E-08	3.3E-06	7.7E-08	6.7E-08	5.9E-08

5.7E-08

Direction	Distance (m)					
	1296	1585	1560	1293	488	809
852						
N	5.9E-08	4.3E-08	4.4E-08	5.9E-08	3.3E-07	1.3E-07
1.2E-07						
NNW	7.9E-08	5.8E-08	6.0E-08	8.0E-08	4.1E-07	1.7E-07
1.6E-07						
NW	8.1E-08	5.9E-08	6.1E-08	8.1E-08	4.1E-07	1.8E-07
1.6E-07						
WNW	5.8E-08	4.3E-08	4.4E-08	5.8E-08	3.5E-07	1.3E-07
1.1E-07						
W	7.1E-08	5.2E-08	5.4E-08	7.1E-08	3.5E-07	1.5E-07
1.4E-07						
WSW	5.4E-08	4.0E-08	4.1E-08	5.4E-08	3.2E-07	1.2E-07
1.1E-07						
SW	6.6E-08	4.8E-08	5.0E-08	6.6E-08	3.7E-07	1.4E-07
1.3E-07						
SSW	8.8E-08	6.5E-08	6.7E-08	8.8E-08	4.9E-07	1.9E-07
1.7E-07						
S	1.2E-07	8.9E-08	9.1E-08	1.2E-07	6.5E-07	2.6E-07
2.4E-07						
SSE	1.5E-07	1.1E-07	1.2E-07	1.5E-07	7.6E-07	3.3E-07
3.0E-07						
SE	1.2E-07	8.8E-08	9.0E-08	1.2E-07	6.5E-07	2.6E-07
2.4E-07						
ESE	8.8E-08	6.5E-08	6.6E-08	8.9E-08	5.1E-07	1.9E-07
1.8E-07						
E	8.5E-08	6.2E-08	6.4E-08	8.5E-08	4.4E-07	1.9E-07
1.7E-07						
ENE	5.7E-08	4.2E-08	4.3E-08	5.8E-08	3.6E-07	1.3E-07
1.1E-07						
NE	7.4E-08	5.4E-08	5.6E-08	7.4E-08	3.6E-07	1.6E-07
1.5E-07						
NNE	5.1E-08	3.7E-08	3.8E-08	5.1E-08	3.0E-07	1.1E-07
1.0E-07						

C A P 8 8 - P C

Version 1.00

Clean Air Act Assessment Package - 1988

DOSE AND RISK EQUIVALENT SUMMARIES

Radon Individual Assessment
Dec 23, 1993 1:12 pm

Facility: ARCO Bluewater Mill

Address: P.O. Box 628

City: Grants
State: NM Zip: 87020-0638

Source Category: Uranium Mill Tailings-RADON

Source Type: Area
Emission Year: 94

Comments: For analysis of off-pile remediated site

Dataset Name: RADON 6
Dataset Date: Dec 23, 1993 1:12 pm
Wind File: WNDFILES\STARANHM.WND

INDIVIDUAL EFFECTIVE DOSE EQUIVALENT RATE (mrem/y)
(All Radionuclides and Pathways)

	Distance (m)					
Direction	547	658	74	165	198	274
N	1.4E-03	9.6E-04	8.6E-02	1.8E-02	1.1E-02	5.3E-03
NNW	1.7E-03	1.2E-03	8.6E-02	1.7E-02	1.1E-02	6.2E-03
NW	1.7E-03	1.3E-03	8.6E-02	1.8E-02	1.2E-02	6.2E-03
WNW	1.4E-03	9.7E-04	8.6E-02	1.8E-02	1.1E-02	5.9E-03
W	1.5E-03	1.1E-03	8.6E-02	1.7E-02	1.1E-02	5.2E-03
WSW	1.3E-03	9.0E-04	8.6E-02	1.8E-02	1.1E-02	5.4E-03
SW	1.5E-03	1.1E-03	8.6E-02	2.1E-02	1.3E-02	5.9E-03
SSW	2.0E-03	1.4E-03	8.6E-02	2.5E-02	1.6E-02	7.8E-03
S	2.7E-03	1.9E-03	8.6E-02	2.9E-02	1.9E-02	1.0E-02
SSE	3.2E-03	2.4E-03	8.6E-02	3.0E-02	2.0E-02	1.1E-02
SE	2.7E-03	1.9E-03	8.6E-02	2.9E-02	1.9E-02	1.0E-02
ESE	2.1E-03	1.5E-03	8.6E-02	2.6E-02	1.7E-02	8.3E-03
E	1.9E-03	1.3E-03	8.6E-02	2.2E-02	1.4E-02	6.6E-03
ENE	1.5E-03	9.8E-04	8.6E-02	1.8E-02	1.2E-02	6.1E-03
NE	1.5E-03	1.1E-03	8.6E-02	1.7E-02	1.1E-02	5.2E-03
NNE	1.3E-03	8.5E-04	8.6E-02	1.6E-02	1.0E-02	5.2E-03

INDIVIDUAL LIFETIME RISK (deaths)
(All Radionuclides and Pathways)

	Distance (m)					
Direction	547	658	74	165	198	274
N	2.6E-07	1.9E-07	1.5E-05	3.1E-06	2.0E-06	9.7E-07
NNW	3.3E-07	2.4E-07	1.5E-05	3.1E-06	2.0E-06	1.1E-06
NW	3.3E-07	2.4E-07	1.5E-05	3.2E-06	2.1E-06	1.1E-06
WNW	2.7E-07	1.9E-07	1.5E-05	3.2E-06	2.1E-06	1.1E-06
W	2.9E-07	2.1E-07	1.5E-05	3.1E-06	1.9E-06	9.5E-07
WSW	2.5E-07	1.7E-07	1.5E-05	3.1E-06	2.0E-06	9.9E-07
SW	2.9E-07	2.1E-07	1.5E-05	3.7E-06	2.3E-06	1.1E-06
SSW	3.9E-07	2.8E-07	1.5E-05	4.5E-06	2.8E-06	1.4E-06
S	5.2E-07	3.7E-07	1.5E-05	5.1E-06	3.4E-06	1.9E-06
SSE	6.1E-07	4.6E-07	1.5E-05	5.4E-06	3.6E-06	2.0E-06
SE	5.2E-07	3.7E-07	1.5E-05	5.3E-06	3.5E-06	1.9E-06
ESE	4.0E-07	2.8E-07	1.5E-05	4.7E-06	3.0E-06	1.5E-06
E	3.5E-07	2.6E-07	1.5E-05	3.9E-06	2.5E-06	1.2E-06
ENE	2.8E-07	1.9E-07	1.5E-05	3.3E-06	2.1E-06	1.1E-06
NE	2.9E-07	2.2E-07	1.5E-05	3.0E-06	1.9E-06	9.4E-07
NNE	2.4E-07	1.6E-07	1.5E-05	2.9E-06	1.9E-06	9.4E-07

Appendix E

CAP88-PC Runs for Population EDE Assessments

C A P 8 8 - P C

Version 1.00

Clean Air Act Assessment Package - 1988

DOSE AND RISK EQUIVALENT SUMMARIES

Non-Radon Population Assessment
Dec 16, 1993 1:10 pm

Facility: ARCO Bluewater Mill

Address: P.O. Box 628

City: Grants
State: NM Zip: 87020-0638

Source Category: Uranium Mill Tailings-particulate

Source Type: Area
Emission Year: 94

Comments: For analysis of off-pile remediated site

Dataset Name: population1
Dataset Date: Dec 16, 1993 1:10 pm
Wind File: WNDFILES\STARANHM.WND

Population File: POPFILES\BLUEWATE.POP

ORGAN DOSE EQUIVALENT SUMMARY
(RN-222 Working Level Calculations Excluded)

Organ	Selected Individual (mrem/y)	Collective Population (person-rem/y)
GONADS	1.36E-05	4.95E-05
BREAST	1.38E-05	5.00E-05
R MAR	5.23E-04	1.64E-03
LUNGS	2.89E-03	8.72E-03
THYROID	1.36E-05	4.93E-05
ENDOST	6.46E-03	2.02E-02
RMNDR	2.44E-05	8.96E-05
EFFEC	6.16E-04	1.90E-03

Radon Decay Product Concentration (working level)

0.00E+00 0.00E+00

PATHWAY EFFECTIVE DOSE EQUIVALENT SUMMARY
(RN-222 Working Level Calculations Excluded)

Pathway	Selected Individual (mrem/y)	Collective Population (person-rem/y)
INGESTION	4.55E-05	1.78E-04
INHALATION	5.70E-04	1.72E-03
AIR IMMERSION	4.18E-10	1.08E-09
GROUND SURFACE	5.74E-07	1.90E-06

INTERNAL	6.16E-04	1.90E-03
EXTERNAL	5.75E-07	1.90E-06
TOTAL	6.16E-04	1.90E-03

Radon Decay Product Concentration (working level)

0.00E+00	0.00E+00

NUCLIDE EFFECTIVE DOSE EQUIVALENT SUMMARY
(RN-222 Working Level Calculations Excluded)

Nuclides	Selected Individual (mrem/y)	Collective Population (person-rem/y)
RN-222	0.00E+00	0.00E+00
RA-226	7.39E-05	2.55E-04
TH-230	4.54E-04	1.37E-03
U-234	4.68E-05	1.43E-04
U-238	4.17E-05	1.28E-04
PA-234	1.02E-09	2.67E-09
TH-234	2.53E-08	8.72E-08
TOTAL	6.16E-04	1.90E-03

Radon Decay Product Concentration (working level)

0.00E+00 0.00E+00

CANCER RISK SUMMARY

Cancer	Selected Individual Total Lifetime Fatal Cancer Risk	Total Collective Population Fatal Cancer Risk (Deaths/y)
LEUKEMIA	4.56E-10	2.04E-08
BONE	2.94E-10	1.31E-08
THYROID	2.51E-12	1.28E-10
BREAST	2.19E-11	1.11E-09
LUNG	5.03E-09	2.15E-07
STOMACH	1.70E-11	8.70E-10
BOWEL	1.33E-11	6.93E-10
LIVER	2.65E-11	1.28E-09
PANCREAS	1.25E-11	6.41E-10
URINARY	2.02E-11	1.08E-09
OTHER	1.53E-11	7.84E-10
TOTAL	5.91E-09	2.55E-07

	Selected Individual Cancer Risk	Collective Population Cancer Risk (Deaths/y)
Radon Decay Product Lung Exposure	0.00E+00	0.00E+00
Total Fatal Risk All Exposures	5.91E-09	2.55E-07

PATHWAY RISK SUMMARY

Pathway	Selected Individual Total Lifetime Fatal Cancer Risk	Total Collective Population Fatal Cancer Risk (Deaths/y)
INGESTION	2.20E-10	1.22E-08
INHALATION	5.68E-09	2.42E-07
AIR IMMERSION	1.00E-14	3.65E-13
GROUND SURFACE	1.33E-11	6.24E-10
INTERNAL	5.90E-09	2.54E-07
EXTERNAL	1.34E-11	6.24E-10
TOTAL	5.91E-09	2.55E-07

	Selected Individual Cancer Risk	Collective Population Cancer Risk (Deaths/y)
Radon Decay Product Lung Exposure	0.00E+00	0.00E+00
Total Fatal Risk All Exposures	5.91E-09	2.55E-07

PATHWAY GENETIC RISK SUMMARY
(Collective Population)

Pathway	Genetic Risk (person-rem/y)

INGESTION	4.45E-06
INHALATION	1.35E-06
AIR IMMERSION	1.06E-09
GROUND SURFACE	1.70E-06
INTERNAL	5.80E-06
EXTERNAL	1.70E-06
TOTAL	7.50E-06

NUCLIDE RISK SUMMARY

Nuclide	Selected Individual Total Lifetime Fatal Cancer Risk	Total Collective Population Fatal Cancer Risk (Deaths/y)
RN-222	0.00E+00	0.00E+00
RA-226	1.04E-09	4.65E-08
TH-230	3.72E-09	1.59E-07
U-234	6.05E-10	2.59E-08
U-238	5.43E-10	2.33E-08
PA-234	2.62E-14	9.69E-13
TH-234	8.51E-13	3.80E-11
TOTAL	5.91E-09	2.55E-07

NUCLIDE RISK SUMMARY
(Continued)

	Selected Individual Cancer Risk	Collective Population Cancer Risk (Deaths/y)
Radon Decay Product		
Lung Exposure	0.00E+00	0.00E+00
Total Fatal Risk		
All Exposures	5.91E-09	2.55E-07

INDIVIDUAL EFFECTIVE DOSE EQUIVALENT RATE (mrem/y)
(All Radionuclides and Pathways)

	Distance (m)						
Direction	250	750	1500	2500	3500	4500	7500
N	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
NNW	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
NW	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.3E-04	0.0E+00
WNW	0.0E+00	0.0E+00	0.0E+00	4.0E-04	2.3E-04	1.6E-04	0.0E+00
W	0.0E+00	0.0E+00	0.0E+00	4.8E-04	2.8E-04	0.0E+00	0.0E+00
WSW	0.0E+00	0.0E+00	0.0E+00	3.7E-04	2.1E-04	1.5E-04	0.0E+00
SW	0.0E+00	0.0E+00	0.0E+00	4.4E-04	2.5E-04	1.7E-04	7.7E-05
SSW	0.0E+00	0.0E+00	0.0E+00	6.0E-04	3.5E-04	2.4E-04	0.0E+00
S	0.0E+00	0.0E+00	0.0E+00	0.0E+00	4.8E-04	3.3E-04	0.0E+00
SSE	0.0E+00	0.0E+00	0.0E+00	0.0E+00	6.2E-04	4.2E-04	1.9E-04
SE	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.5E-04
ESE	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
E	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
ENE	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	7.4E-05
NE	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
NNE	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00

	Distance (m)					
Direction	15000	25000	35000	45000	55000	70000
N	0.0E+00	1.4E-05	9.0E-06	6.4E-06	0.0E+00	3.3E-06
NNW	3.9E-05	1.9E-05	1.2E-05	8.8E-06	6.5E-06	4.5E-06
NW	4.1E-05	2.0E-05	1.3E-05	9.3E-06	6.9E-06	4.7E-06
WNW	2.8E-05	1.3E-05	0.0E+00	6.1E-06	4.5E-06	2.9E-06
W	3.3E-05	1.6E-05	0.0E+00	0.0E+00	5.3E-06	3.4E-06
WSW	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.7E-06
SW	0.0E+00	1.3E-05	8.7E-06	0.0E+00	0.0E+00	0.0E+00

SSW	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	4.0E-06
S	0.0E+00	2.6E-05	0.0E+00	1.1E-05	0.0E+00	5.3E-06
SSE	7.1E-05	0.0E+00	2.2E-05	1.5E-05	1.1E-05	7.1E-06
SE	5.6E-05	2.7E-05	1.7E-05	1.2E-05	8.8E-06	5.8E-06
ESE	0.0E+00	2.0E-05	0.0E+00	9.1E-06	6.7E-06	4.5E-06
E	0.0E+00	2.0E-05	0.0E+00	0.0E+00	6.8E-06	0.0E+00
ENE	0.0E+00	0.0E+00	0.0E+00	5.9E-06	4.4E-06	0.0E+00
NE	0.0E+00	1.6E-05	0.0E+00	0.0E+00	0.0E+00	3.7E-06
NNE	2.3E-05	0.0E+00	0.0E+00	5.1E-06	0.0E+00	2.6E-06

COLLECTIVE EFFECTIVE DOSE EQUIVALENT (person rem/y)
(All Radionuclides and Pathways)

	Distance (m)						
Direction	250	750	1500	2500	3500	4500	7500
N	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
NNW	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
NW	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.1E-06	0.0E+00
WNW	0.0E+00	0.0E+00	0.0E+00	1.6E-06	3.3E-06	7.3E-06	0.0E+00
W	0.0E+00	0.0E+00	0.0E+00	1.9E-06	2.5E-06	0.0E+00	0.0E+00
WSW	0.0E+00	0.0E+00	0.0E+00	3.3E-06	1.9E-05	1.3E-05	0.0E+00
SW	0.0E+00	0.0E+00	0.0E+00	1.7E-06	2.3E-05	1.5E-05	1.2E-04
SSW	0.0E+00	0.0E+00	0.0E+00	2.4E-06	7.0E-07	9.7E-06	0.0E+00
S	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.4E-06	1.6E-06	0.0E+00
SSE	0.0E+00	0.0E+00	0.0E+00	0.0E+00	4.9E-06	5.5E-06	4.7E-04
SE	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	4.3E-06
ESE	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
E	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
ENE	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	6.6E-05
NE	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
NNE	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00

	Distance (m)					
Direction	15000	25000	35000	45000	55000	70000
N	0.0E+00	7.5E-07	2.8E-06	3.8E-06	0.0E+00	5.5E-07
NNW	2.2E-05	3.0E-06	6.6E-06	1.2E-05	2.1E-06	1.8E-06
NW	2.4E-06	2.5E-06	1.5E-06	6.1E-06	4.9E-06	8.2E-06
WNW	2.2E-05	1.6E-05	0.0E+00	3.5E-06	3.4E-06	6.0E-05
W	4.7E-07	3.5E-06	0.0E+00	0.0E+00	6.4E-08	3.1E-06
WSW	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.9E-06
SW	0.0E+00	1.1E-07	7.4E-06	0.0E+00	0.0E+00	0.0E+00

SSW	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	6.0E-08
S	0.0E+00	3.0E-05	0.0E+00	8.0E-06	0.0E+00	9.6E-08
SSE	2.3E-04	0.0E+00	4.3E-08	1.5E-08	9.7E-07	2.8E-08
SE	5.4E-04	2.5E-06	1.6E-05	1.6E-05	8.8E-09	4.7E-08
ESE	0.0E+00	1.5E-05	0.0E+00	9.5E-06	1.6E-05	4.4E-06
E	0.0E+00	2.9E-05	0.0E+00	0.0E+00	3.6E-06	0.0E+00
ENE	0.0E+00	0.0E+00	0.0E+00	4.1E-08	3.5E-08	0.0E+00
NE	0.0E+00	4.6E-07	0.0E+00	0.0E+00	0.0E+00	5.5E-07
NNE	2.9E-06	0.0E+00	0.0E+00	4.9E-07	0.0E+00	1.8E-06

AVERAGE COLLECTIVE GENETIC DOSE EQUIVALENT
(person rem)
(All Radionuclides and Pathways)

	Distance (m)						
Direction	250	750	1500	2500	3500	4500	7500
N	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
NNW	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
NW	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.3E-06	0.0E+00
WNW	0.0E+00	0.0E+00	0.0E+00	9.3E-07	1.9E-06	4.4E-06	0.0E+00
W	0.0E+00	0.0E+00	0.0E+00	1.1E-06	1.5E-06	0.0E+00	0.0E+00
WSW	0.0E+00	0.0E+00	0.0E+00	1.9E-06	1.1E-05	7.9E-06	0.0E+00
SW	0.0E+00	0.0E+00	0.0E+00	1.0E-06	1.3E-05	9.3E-06	7.4E-05
SSW	0.0E+00	0.0E+00	0.0E+00	1.4E-06	4.1E-07	5.8E-06	0.0E+00
S	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.0E-06	9.8E-07	0.0E+00
SSE	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.9E-06	3.3E-06	2.9E-04
SE	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.7E-06
ESE	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
E	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
ENE	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	4.3E-05
NE	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
NNE	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00

	Distance (m)					
Direction	15000	25000	35000	45000	55000	70000
N	0.0E+00	6.1E-07	2.5E-06	3.8E-06	0.0E+00	7.4E-07
NNW	1.5E-05	2.3E-06	5.5E-06	1.1E-05	2.1E-06	2.1E-06
NW	1.6E-06	1.8E-06	1.3E-06	5.4E-06	4.7E-06	9.3E-06
WNW	1.5E-05	1.2E-05	0.0E+00	3.4E-06	3.8E-06	8.3E-05
W	3.1E-07	2.6E-06	0.0E+00	0.0E+00	6.6E-08	4.0E-06
WSW	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.7E-06

SW	0.0E+00	8.6E-08	6.6E-06	0.0E+00	0.0E+00	0.0E+00
SSW	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	7.2E-08
S	0.0E+00	2.1E-05	0.0E+00	6.7E-06	0.0E+00	1.0E-07
SSE	1.5E-04	0.0E+00	3.2E-08	1.2E-08	8.3E-07	2.8E-08
SE	3.6E-04	1.8E-06	1.3E-05	1.3E-05	8.1E-09	4.9E-08
ESE	0.0E+00	1.1E-05	0.0E+00	8.6E-06	1.6E-05	5.1E-06
E	0.0E+00	2.3E-05	0.0E+00	0.0E+00	3.7E-06	0.0E+00
ENE	0.0E+00	0.0E+00	0.0E+00	4.4E-08	4.3E-08	0.0E+00
NE	0.0E+00	3.7E-07	0.0E+00	0.0E+00	0.0E+00	7.2E-07
NNE	2.1E-06	0.0E+00	0.0E+00	5.4E-07	0.0E+00	2.8E-06

INDIVIDUAL LIFETIME RISK (deaths)
(All Radionuclides and Pathways)

	Distance (m)						
Direction	250	750	1500	2500	3500	4500	7500
N	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
NNW	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
NW	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.3E-09	0.0E+00
WNW	0.0E+00	0.0E+00	0.0E+00	3.9E-09	2.2E-09	1.5E-09	0.0E+00
W	0.0E+00	0.0E+00	0.0E+00	4.6E-09	2.7E-09	0.0E+00	0.0E+00
WSW	0.0E+00	0.0E+00	0.0E+00	3.6E-09	2.1E-09	1.4E-09	0.0E+00
SW	0.0E+00	0.0E+00	0.0E+00	4.2E-09	2.4E-09	1.6E-09	7.3E-10
SSW	0.0E+00	0.0E+00	0.0E+00	5.8E-09	3.3E-09	2.3E-09	0.0E+00
S	0.0E+00	0.0E+00	0.0E+00	0.0E+00	4.6E-09	3.1E-09	0.0E+00
SSE	0.0E+00	0.0E+00	0.0E+00	0.0E+00	5.9E-09	4.0E-09	1.8E-09
SE	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.5E-09
ESE	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
E	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
ENE	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	7.0E-10
NE	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
NNE	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00

	Distance (m)					
Direction	15000	25000	35000	45000	55000	70000
N	0.0E+00	1.3E-10	8.3E-11	5.9E-11	0.0E+00	3.0E-11
NNW	3.7E-10	1.8E-10	1.1E-10	8.1E-11	6.0E-11	4.1E-11
NW	3.9E-10	1.9E-10	1.2E-10	8.6E-11	6.4E-11	4.3E-11
WNW	2.6E-10	1.2E-10	0.0E+00	5.6E-11	4.1E-11	2.6E-11
W	3.2E-10	1.5E-10	0.0E+00	0.0E+00	4.9E-11	3.0E-11
WSW	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.3E-11
SW	0.0E+00	1.3E-10	8.1E-11	0.0E+00	0.0E+00	0.0E+00

SSW	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.6E-11
S	0.0E+00	2.4E-10	0.0E+00	1.1E-10	0.0E+00	4.9E-11
SSE	6.8E-10	0.0E+00	2.0E-10	1.4E-10	1.0E-10	6.5E-11
SE	5.4E-10	2.6E-10	1.6E-10	1.1E-10	8.2E-11	5.3E-11
ESE	0.0E+00	1.9E-10	0.0E+00	8.5E-11	6.2E-11	4.0E-11
E	0.0E+00	1.9E-10	0.0E+00	0.0E+00	6.3E-11	0.0E+00
ENE	0.0E+00	0.0E+00	0.0E+00	5.4E-11	4.0E-11	0.0E+00
NE	0.0E+00	1.5E-10	0.0E+00	0.0E+00	0.0E+00	3.3E-11
NNE	2.2E-10	0.0E+00	0.0E+00	4.7E-11	0.0E+00	2.3E-11

COLLECTIVE FATAL CANCER RATE (deaths/y)
(All Radionuclides and Pathways)

	Distance (m)						
Direction	250	750	1500	2500	3500	4500	7500
N	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
NNW	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
NW	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.9E-10	0.0E+00
WNW	0.0E+00	0.0E+00	0.0E+00	2.2E-10	4.4E-10	1.0E-09	0.0E+00
W	0.0E+00	0.0E+00	0.0E+00	2.6E-10	3.4E-10	0.0E+00	0.0E+00
WSW	0.0E+00	0.0E+00	0.0E+00	4.5E-10	2.6E-09	1.8E-09	0.0E+00
SW	0.0E+00	0.0E+00	0.0E+00	2.4E-10	3.1E-09	2.1E-09	1.6E-08
SSW	0.0E+00	0.0E+00	0.0E+00	3.3E-10	9.4E-11	1.3E-09	0.0E+00
S	0.0E+00	0.0E+00	0.0E+00	0.0E+00	4.6E-10	2.2E-10	0.0E+00
SSE	0.0E+00	0.0E+00	0.0E+00	0.0E+00	6.7E-10	7.4E-10	6.3E-08
SE	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	5.8E-10
ESE	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
E	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
ENE	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	8.9E-09
NE	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
NNE	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00

	Distance (m)					
Direction	15000	25000	35000	45000	55000	70000
N	0.0E+00	9.9E-11	3.7E-10	4.9E-10	0.0E+00	6.9E-11
NNW	2.9E-09	4.0E-10	8.7E-10	1.5E-09	2.7E-10	2.3E-10
NW	3.2E-10	3.3E-10	2.0E-10	8.0E-10	6.3E-10	1.1E-09
WNW	2.9E-09	2.1E-09	0.0E+00	4.6E-10	4.4E-10	7.5E-09
W	6.3E-11	4.7E-10	0.0E+00	0.0E+00	8.3E-12	4.0E-10
WSW	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.3E-10
SW	0.0E+00	1.4E-11	9.7E-10	0.0E+00	0.0E+00	0.0E+00

SSW	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	7.7E-12
S	0.0E+00	4.0E-09	0.0E+00	1.1E-09	0.0E+00	1.2E-11
SSE	3.0E-08	0.0E+00	5.8E-12	2.0E-12	1.3E-10	3.7E-12
SE	7.3E-08	3.3E-10	2.1E-09	2.1E-09	1.2E-12	6.0E-12
ESE	0.0E+00	2.0E-09	0.0E+00	1.2E-09	2.0E-09	5.6E-10
E	0.0E+00	3.9E-09	0.0E+00	0.0E+00	4.7E-10	0.0E+00
ENE	0.0E+00	0.0E+00	0.0E+00	5.3E-12	4.5E-12	0.0E+00
NE	0.0E+00	6.1E-11	0.0E+00	0.0E+00	0.0E+00	7.0E-11
NNE	3.9E-10	0.0E+00	0.0E+00	6.3E-11	0.0E+00	2.3E-10

C A P 8 8 - P C

Version 1.00

Clean Air Act Assessment Package - 1988

DOSE AND RISK EQUIVALENT SUMMARIES

Radon Population Assessment
Dec 16, 1993 1:18 pm

Facility: ARCO Bluewater Mill
Address: P.O. Box 628
City: Grants
State: NM Zip: 87020-0638

Source Category: Uranium Mill Tailings-radon
Source Type: Area
Emission Year: 94

Comments: For analysis of off-pile remediated site

Dataset Name: population2
Dataset Date: Dec 16, 1993 1:17 pm
Wind File: WNDFILES\STARANHM.WND
Population File: POPFILES\BLUEWATE.POP

ORGAN DOSE EQUIVALENT SUMMARY

Organ	Selected Individual (mrem/y)	Collective Population (person-rem/y)
GONADS	1.40E-04	4.76E-04
BREAST	1.40E-04	4.76E-04
R MAR	4.17E-05	1.42E-04
LUNGS	2.48E-04	8.45E-04
THYROID	1.40E-04	4.76E-04
ENDOST	2.00E-04	6.83E-04
RMNDR	1.40E-04	4.76E-04
EFFEC	1.43E-04	4.86E-04

Radon Decay Product Concentration (working level)

2.65E-08 1.36E-04

PATHWAY EFFECTIVE DOSE EQUIVALENT SUMMARY

Pathway	Selected Individual (mrem/y)	Collective Population (person-rem/y)
INGESTION	0.00E+00	0.00E+00
INHALATION	1.43E-04	4.86E-04
AIR IMMERSION	1.29E-08	4.39E-08
GROUND SURFACE	0.00E+00	0.00E+00
INTERNAL	1.43E-04	4.86E-04
EXTERNAL	1.29E-08	4.39E-08

TOTAL	1.43E-04	4.86E-04

Radon Decay Product Concentration (working level)

2.65E-08	1.36E-04

No Ground Surface Concentration or Ingestion Rate
Exposures for RN-222

NUCLIDE EFFECTIVE DOSE EQUIVALENT SUMMARY

Nuclides	Selected Individual (mrem/y)	Collective Population (person-rem/y)
RN-222	1.43E-04	4.86E-04
TOTAL	1.43E-04	4.86E-04

Radon Decay Product Concentration (working level)

2.65E-08 1.36E-04

CANCER RISK SUMMARY

Cancer	Selected Individual Total Lifetime Fatal Cancer Risk	Total Collective Population Fatal Cancer Risk (Deaths/y)
LEUKEMIA	5.34E-11	2.57E-09
BONE	1.42E-11	6.84E-10
THYROID	2.55E-11	1.23E-09
BREAST	2.20E-10	1.06E-08
LUNG	6.45E-10	3.11E-08
STOMACH	1.83E-10	8.79E-09
BOWEL	9.12E-11	4.39E-09
LIVER	5.49E-11	2.65E-09
PANCREAS	1.37E-10	6.62E-09
URINARY	2.06E-11	9.92E-10
OTHER	1.68E-10	8.10E-09
TOTAL	1.61E-09	7.77E-08

	Selected Individual Cancer Risk	Collective Population Cancer Risk (Deaths/y)
Radon Decay Product Lung Exposure	3.49E-08	2.53E-06
Total Fatal Risk All Exposures	3.65E-08	2.61E-06

PATHWAY RISK SUMMARY

Pathway	Selected Individual Total Lifetime Fatal Cancer Risk	Total Collective Population Fatal Cancer Risk (Deaths/y)
INGESTION	0.00E+00	0.00E+00
INHALATION	1.61E-09	7.77E-08
AIR IMMERSION	3.08E-13	1.48E-11
GROUND SURFACE	0.00E+00	0.00E+00
INTERNAL	1.61E-09	7.77E-08
EXTERNAL	3.08E-13	1.48E-11
TOTAL	1.61E-09	7.77E-08

	Selected Individual Cancer Risk	Collective Population Cancer Risk (Deaths/y)
Radon Decay Product Lung Exposure	3.49E-08	2.53E-06
Total Fatal Risk All Exposures	3.65E-08	2.61E-06

PATHWAY GENETIC RISK SUMMARY
(Collective Population)

Pathway	Genetic Risk (person-rem/y)

INGESTION	0.00E+00
INHALATION	6.48E-05
AIR IMMERSION	4.32E-08
GROUND SURFACE	0.00E+00
INTERNAL	6.48E-05
EXTERNAL	4.32E-08
TOTAL	6.48E-05

NUCLIDE RISK SUMMARY

Nuclide	Selected Individual Total Lifetime Fatal Cancer Risk	Total Collective Population Fatal Cancer Risk (Deaths/y)
RN-222	1.61E-09	7.77E-08
TOTAL	1.61E-09	7.77E-08

NUCLIDE RISK SUMMARY
(Continued)

	Selected Individual Cancer Risk	Collective Population Cancer Risk (Deaths/y)
Radon Decay Product		
Lung Exposure	3.49E-08	2.53E-06
Total Fatal Risk		
All Exposures	3.65E-08	2.61E-06

INDIVIDUAL EFFECTIVE DOSE EQUIVALENT RATE (mrem/y)
(All Radionuclides and Pathways)

	Distance (m)						
Direction	250	750	1500	2500	3500	4500	7500
N	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
NNW	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
NW	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	5.2E-05	0.0E+00
WNW	0.0E+00	0.0E+00	0.0E+00	9.3E-05	5.5E-05	3.8E-05	0.0E+00
W	0.0E+00	0.0E+00	0.0E+00	1.1E-04	6.8E-05	0.0E+00	0.0E+00
WSW	0.0E+00	0.0E+00	0.0E+00	8.7E-05	5.1E-05	3.6E-05	0.0E+00
SW	0.0E+00	0.0E+00	0.0E+00	1.0E-04	6.1E-05	4.2E-05	2.0E-05
SSW	0.0E+00	0.0E+00	0.0E+00	1.4E-04	8.3E-05	5.7E-05	0.0E+00
S	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.1E-04	7.8E-05	0.0E+00
SSE	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.4E-04	9.8E-05	4.7E-05
SE	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.6E-05
ESE	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
E	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
ENE	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.6E-05
NE	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
NNE	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00

	Distance (m)					
Direction	15000	25000	35000	45000	55000	70000
N	0.0E+00	3.5E-06	2.3E-06	1.7E-06	0.0E+00	9.5E-07
NNW	9.0E-06	4.7E-06	3.0E-06	2.2E-06	1.7E-06	1.2E-06
NW	9.6E-06	5.0E-06	3.3E-06	2.4E-06	1.9E-06	1.4E-06
WNW	7.3E-06	3.9E-06	0.0E+00	1.9E-06	1.5E-06	1.1E-06
W	9.3E-06	5.1E-06	0.0E+00	0.0E+00	2.0E-06	1.5E-06
WSW	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.0E-06
SW	0.0E+00	4.3E-06	2.8E-06	0.0E+00	0.0E+00	0.0E+00

SSW	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.6E-06
S	0.0E+00	7.5E-06	0.0E+00	3.6E-06	0.0E+00	2.0E-06
SSE	1.8E-05	0.0E+00	6.3E-06	4.6E-06	3.6E-06	2.6E-06
SE	1.4E-05	7.3E-06	4.8E-06	3.5E-06	2.7E-06	2.0E-06
ESE	0.0E+00	5.5E-06	0.0E+00	2.6E-06	2.0E-06	1.5E-06
E	0.0E+00	4.9E-06	0.0E+00	0.0E+00	1.8E-06	0.0E+00
ENE	0.0E+00	0.0E+00	0.0E+00	1.4E-06	1.1E-06	0.0E+00
NE	0.0E+00	4.0E-06	0.0E+00	0.0E+00	0.0E+00	1.0E-06
NNE	5.7E-06	0.0E+00	0.0E+00	1.4E-06	0.0E+00	7.7E-07

COLLECTIVE EFFECTIVE DOSE EQUIVALENT (person rem/y)
(All Radionuclides and Pathways)

	Distance (m)						
Direction	250	750	1500	2500	3500	4500	7500
N	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
NNW	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
NW	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	4.7E-07	0.0E+00
WNW	0.0E+00	0.0E+00	0.0E+00	3.7E-07	7.7E-07	1.8E-06	0.0E+00
W	0.0E+00	0.0E+00	0.0E+00	4.6E-07	6.1E-07	0.0E+00	0.0E+00
WSW	0.0E+00	0.0E+00	0.0E+00	7.8E-07	4.6E-06	3.2E-06	0.0E+00
SW	0.0E+00	0.0E+00	0.0E+00	4.2E-07	5.5E-06	3.8E-06	3.0E-05
SSW	0.0E+00	0.0E+00	0.0E+00	5.6E-07	1.7E-07	2.4E-06	0.0E+00
S	0.0E+00	0.0E+00	0.0E+00	0.0E+00	7.9E-07	3.9E-07	0.0E+00
SSE	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.1E-06	1.3E-06	1.1E-04
SE	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.0E-06
ESE	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
E	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
ENE	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.5E-05
NE	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
NNE	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00

	Distance (m)					
Direction	15000	25000	35000	45000	55000	70000
N	0.0E+00	1.9E-07	7.1E-07	9.7E-07	0.0E+00	1.6E-07
NNW	5.0E-06	7.3E-07	1.6E-06	2.9E-06	5.5E-07	5.0E-07
NW	5.7E-07	6.1E-07	3.9E-07	1.6E-06	1.3E-06	2.4E-06
WNW	5.8E-06	4.7E-06	0.0E+00	1.1E-06	1.1E-06	2.3E-05
W	1.3E-07	1.1E-06	0.0E+00	0.0E+00	2.4E-08	1.4E-06
WSW	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	7.3E-07
SW	0.0E+00	3.4E-08	2.4E-06	0.0E+00	0.0E+00	0.0E+00

SSW	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.4E-08
S	0.0E+00	8.6E-06	0.0E+00	2.5E-06	0.0E+00	3.6E-08
SSE	5.8E-05	0.0E+00	1.3E-08	4.6E-09	3.2E-07	1.1E-08
SE	1.3E-04	6.7E-07	4.5E-06	4.5E-06	2.7E-09	1.6E-08
ESE	0.0E+00	4.1E-06	0.0E+00	2.7E-06	4.7E-06	1.5E-06
E	0.0E+00	7.2E-06	0.0E+00	0.0E+00	9.5E-07	0.0E+00
ENE	0.0E+00	0.0E+00	0.0E+00	9.8E-09	8.6E-09	0.0E+00
NE	0.0E+00	1.1E-07	0.0E+00	0.0E+00	0.0E+00	1.5E-07
NNE	7.1E-07	0.0E+00	0.0E+00	1.3E-07	0.0E+00	5.4E-07

AVERAGE COLLECTIVE GENETIC DOSE EQUIVALENT
(person rem)
(All Radionuclides and Pathways)

	Distance (m)						
Direction	250	750	1500	2500	3500	4500	7500
N	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
NNW	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
NW	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.4E-05	0.0E+00
WNW	0.0E+00	0.0E+00	0.0E+00	1.1E-05	2.3E-05	5.2E-05	0.0E+00
W	0.0E+00	0.0E+00	0.0E+00	1.3E-05	1.8E-05	0.0E+00	0.0E+00
WSW	0.0E+00	0.0E+00	0.0E+00	2.3E-05	1.4E-04	9.4E-05	0.0E+00
SW	0.0E+00	0.0E+00	0.0E+00	1.2E-05	1.6E-04	1.1E-04	8.9E-04
SSW	0.0E+00	0.0E+00	0.0E+00	1.7E-05	4.9E-06	6.9E-05	0.0E+00
S	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.3E-05	1.1E-05	0.0E+00
SSE	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.3E-05	3.8E-05	3.3E-03
SE	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.0E-05
ESE	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
E	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
ENE	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	4.3E-04
NE	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
NNE	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00

	Distance (m)					
Direction	15000	25000	35000	45000	55000	70000
N	0.0E+00	5.5E-06	2.1E-05	2.9E-05	0.0E+00	4.6E-06
NNW	1.5E-04	2.1E-05	4.8E-05	8.6E-05	1.6E-05	1.5E-05
NW	1.7E-05	1.8E-05	1.1E-05	4.6E-05	3.8E-05	7.0E-05
WNW	1.7E-04	1.4E-04	0.0E+00	3.2E-05	3.3E-05	6.7E-04
W	3.8E-06	3.3E-05	0.0E+00	0.0E+00	6.9E-07	4.0E-05
WSW	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.2E-05

SW	0.0E+00	1.0E-06	7.1E-05	0.0E+00	0.0E+00	0.0E+00
SSW	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	7.1E-07
S	0.0E+00	2.5E-04	0.0E+00	7.3E-05	0.0E+00	1.1E-06
SSE	1.7E-03	0.0E+00	3.7E-07	1.4E-07	9.3E-06	3.1E-07
SE	3.9E-03	2.0E-05	1.3E-04	1.3E-04	7.9E-08	4.6E-07
ESE	0.0E+00	1.2E-04	0.0E+00	8.0E-05	1.4E-04	4.3E-05
E	0.0E+00	2.1E-04	0.0E+00	0.0E+00	2.8E-05	0.0E+00
ENE	0.0E+00	0.0E+00	0.0E+00	2.9E-07	2.5E-07	0.0E+00
NE	0.0E+00	3.3E-06	0.0E+00	0.0E+00	0.0E+00	4.4E-06
NNE	2.1E-05	0.0E+00	0.0E+00	3.9E-06	0.0E+00	1.6E-05

INDIVIDUAL LIFETIME RISK (deaths)
(All Radionuclides and Pathways)

	Distance (m)						
Direction	250	750	1500	2500	3500	4500	7500
N	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
NNW	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
NW	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.4E-08	0.0E+00
WNW	0.0E+00	0.0E+00	0.0E+00	2.2E-08	1.4E-08	1.1E-08	0.0E+00
W	0.0E+00	0.0E+00	0.0E+00	2.7E-08	1.7E-08	0.0E+00	0.0E+00
WSW	0.0E+00	0.0E+00	0.0E+00	2.0E-08	1.3E-08	9.8E-09	0.0E+00
SW	0.0E+00	0.0E+00	0.0E+00	2.5E-08	1.6E-08	1.2E-08	6.5E-09
SSW	0.0E+00	0.0E+00	0.0E+00	3.3E-08	2.1E-08	1.6E-08	0.0E+00
S	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.9E-08	2.1E-08	0.0E+00
SSE	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.7E-08	2.7E-08	1.5E-08
SE	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.2E-08
ESE	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
E	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
ENE	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	5.3E-09
NE	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
NNE	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00

	Distance (m)					
Direction	15000	25000	35000	45000	55000	70000
N	0.0E+00	1.5E-09	1.0E-09	7.3E-10	0.0E+00	4.2E-10
NNW	3.7E-09	2.1E-09	1.3E-09	9.7E-10	7.5E-10	5.5E-10
NW	3.9E-09	2.2E-09	1.4E-09	1.1E-09	8.2E-10	6.0E-10
WNW	3.0E-09	1.7E-09	0.0E+00	8.4E-10	6.6E-10	4.9E-10
W	3.8E-09	2.2E-09	0.0E+00	0.0E+00	8.6E-10	6.4E-10
WSW	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	4.6E-10
SW	0.0E+00	1.9E-09	1.3E-09	0.0E+00	0.0E+00	0.0E+00

SSW	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	7.1E-10
S	0.0E+00	3.3E-09	0.0E+00	1.6E-09	0.0E+00	8.9E-10
SSE	7.5E-09	0.0E+00	2.8E-09	2.0E-09	1.6E-09	1.2E-09
SE	5.8E-09	3.2E-09	2.1E-09	1.5E-09	1.2E-09	8.7E-10
ESE	0.0E+00	2.4E-09	0.0E+00	1.2E-09	9.0E-10	6.6E-10
E	0.0E+00	2.2E-09	0.0E+00	0.0E+00	7.9E-10	0.0E+00
ENE	0.0E+00	0.0E+00	0.0E+00	6.2E-10	4.7E-10	0.0E+00
NE	0.0E+00	1.8E-09	0.0E+00	0.0E+00	0.0E+00	4.5E-10
NNE	2.4E-09	0.0E+00	0.0E+00	6.1E-10	0.0E+00	3.4E-10

COLLECTIVE FATAL CANCER RATE (deaths/y)
(All Radionuclides and Pathways)

	Distance (m)						
Direction	250	750	1500	2500	3500	4500	7500
N	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
NNW	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
NW	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.8E-09	0.0E+00
WNW	0.0E+00	0.0E+00	0.0E+00	1.2E-09	2.8E-09	6.8E-09	0.0E+00
W	0.0E+00	0.0E+00	0.0E+00	1.5E-09	2.2E-09	0.0E+00	0.0E+00
WSW	0.0E+00	0.0E+00	0.0E+00	2.6E-09	1.7E-08	1.2E-08	0.0E+00
SW	0.0E+00	0.0E+00	0.0E+00	1.4E-09	2.0E-08	1.5E-08	1.4E-07
SSW	0.0E+00	0.0E+00	0.0E+00	1.9E-09	6.0E-10	9.1E-09	0.0E+00
S	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.9E-09	1.5E-09	0.0E+00
SSE	0.0E+00	0.0E+00	0.0E+00	0.0E+00	4.1E-09	5.0E-09	5.2E-07
SE	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	4.7E-09
ESE	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
E	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
ENE	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	6.7E-08
NE	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
NNE	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00

	Distance (m)					
Direction	15000	25000	35000	45000	55000	70000
N	0.0E+00	1.2E-09	4.4E-09	6.1E-09	0.0E+00	9.7E-10
NNW	2.9E-08	4.6E-09	1.0E-08	1.8E-08	3.4E-09	3.1E-09
NW	3.3E-09	3.8E-09	2.4E-09	9.8E-09	8.1E-09	1.5E-08
WNW	3.4E-08	2.9E-08	0.0E+00	6.8E-09	7.1E-09	1.4E-07
W	7.6E-10	7.0E-09	0.0E+00	0.0E+00	1.5E-10	8.5E-09
WSW	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	4.6E-09
SW	0.0E+00	2.1E-10	1.5E-08	0.0E+00	0.0E+00	0.0E+00

SSW	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.5E-10
S	0.0E+00	5.3E-08	0.0E+00	1.5E-08	0.0E+00	2.3E-10
SSE	3.4E-07	0.0E+00	7.9E-11	2.9E-11	2.0E-09	6.6E-11
SE	7.8E-07	4.1E-09	2.8E-08	2.8E-08	1.7E-11	9.8E-11
ESE	0.0E+00	2.6E-08	0.0E+00	1.7E-08	2.9E-08	9.1E-09
E	0.0E+00	4.5E-08	0.0E+00	0.0E+00	5.9E-09	0.0E+00
ENE	0.0E+00	0.0E+00	0.0E+00	6.1E-11	5.4E-11	0.0E+00
NE	0.0E+00	7.0E-10	0.0E+00	0.0E+00	0.0E+00	9.3E-10
NNE	4.1E-09	0.0E+00	0.0E+00	8.2E-10	0.0E+00	3.4E-09